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TAX NEWS: IDENTIFYING TAX EXPECTATIONS FROM MUNICIPAL BONDS WITH AN APPLICATION TO HOUSEHOLD CONSUMPTION

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ABSTRACT

Although theoretical models of household behavior often emphasize fiscal foresight, most empirical studies neglect the role of news, thereby potentially underestimating the total effect of tax changes. Using novel high-frequency bond data, I develop a model of the term structure of municipal yield spreads as a function of future top income tax rates and a risk premium. Testing the model using the presidential elections of 1992 and 2000 as two natural experiments shows that financial markets forecast future tax rates remarkably well in both the short and long run. Combining these market-based tax expectations with consumption data from the Consumer Expenditure Survey, I find that consumption of high-income households increases by close to 1% in response to news of a 1% increase in expected after-tax lifetime income, consistent with the basic rational-expectations life-cycle theory.

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The effectiveness of fiscal policy as a tool to stabilize business cycles is widely debated among both academics and policy-makers, and this debate can become heated at times. A major source of many disagreements is the difficulty in credibly identifying both the timing and the magnitude of expected future tax shocks, and in estimating the transmission of those shocks in the economy through anticipation effects. This paper tackles these problems in the following way: first, it measures the expected timing and magnitude of future personal income tax shocks using a novel high-frequency data set of municipal bond yields with different maturities; second, it combines these market-based expectations with micro-level data from the Consumer Expenditure Survey (CEX) to estimate the effect of tax news shocks on household consumption.

To identify news about future taxes, I exploit the differential tax treatment of two types of bonds. Interest on municipal bonds is tax-exempt, while interest on Treasury bonds is subject to federal income taxes; thus, relative price changes between municipal and Treasury bonds reflect changes in expected future tax rates, holding fixed other risk factors. I go beyond identification of the timing of news to directly measure the entire path of expected tax rates. My tax news shocks measure not only *when* households receive information, but also *what* information they receive. I infer the entire path of expected tax rates over a forecasting horizon of up to 30 years at any given point in time by comparing municipal yield spreads of maturities of 1 to 30 years. The fact that different bonds have different maturities quantifies the degree of tax foresight, since yield spreads of bonds with different maturities reflect information about future taxes over different horizons. To take into account factors other than tax news, I derive a model that relates the term structure of municipal yield spreads to the path of expected tax rates and a risk premium.

Identifying the entire path of expected tax rates is important for testing economic models such as the basic rational-expectations life-cycle model of consumption, which predicts that consumption is a function of after-tax lifetime income, not just current income. Changes in the term structure of municipal yield spreads measure the expected persistence of a tax shock, which is a crucial factor that determines the optimal consumption response according to the theory. For instance, if a tax change is expected to be only transitory, then the theory predicts that consumption does not respond much. On the other hand, if a tax reform is expected to have a large persistent component, then consumption should respond much stronger. Hence, the expected tax rates extracted from the municipal yield spreads allow me to compute the effect of a tax reform on changes in the permanent income of a household.

Data on municipal debt ownership from the Flow of Funds Accounts and the Survey of Consumer Finances (SCF) suggest that the marginal municipal bond investor is a household near the top of the income distribution. The marginal tax rate identified by the municipal yield spread should thus be the personal income tax rate of high-income households. Moreover, the SCF shows that the position of the marginal investor in the income distribution is stable over time. Changes in the yield spread therefore reflect news about future tax rates rather than changes in the marginal investor holding fixed future tax rates.

I formally test this conjecture about the marginal investor's tax rate using the presidential elections of 1992 and 2000 as two natural experiments and daily data from a political prediction market as a source of additional variation. Changes in election probabilities reflect changes in expected future tax rates because each candidate had a very different tax reform proposal during both elections. With this additional data, I show that (i) financial markets have strong fiscal foresight with respect to both the timing and the magnitude of the shocks, and (ii) that the marginal tax rate identified by the municipal yield spread is indeed the personal income tax rate of households near the top of the income distribution.

Finally, I apply the identified changes in expected future tax rates to provide a new test of the basic rational-expectations life-cycle hypothesis. Combining the market-based tax news shocks with data from the CEX, I calculate changes in expected after-tax lifetime income for each household. Rational-expectations life-cycle theory predicts that consumption responds to news about all future after-tax income instead of just the current income. I use a stripped-down version of the theory to impute changes in expected after-tax lifetime liabilities for each household in the CEX based on changes in expected tax rates derived from municipal bonds. This basic model also provides a quantitative interpretation of the estimated response as consumption should move roughly one-for-one with expected after-tax lifetime income. Focusing on the sample of high-income households, for which the identified news shock is most directly related to changes in expected after-tax lifetime income, this paper finds that consumption responds strongly to the bond-based tax news shocks, consistent with rational-expectations life-cycle theory. Consumption of nondurables and services increases by about 1% in response to news of a 1% increase in after-tax lifetime income, and the alternative hypothesis that there is no response to tax news is strongly rejected.

To the best of my knowledge, this paper provides the first direct estimates of the effect of news about future after-tax income on consumption at the household-level.[1] The lack of direct estimates of news effects at the household-level is due primarily to the difficulty in identifying expectations about future income changes that vary across households. Previous research either uses survey expectations–which are based on responses to hypothetical questions (for example, how much would you spend now if your income went up by $1,000 next year?) and thus could be different from actual choices made by households–or estimates news shocks directly from observed behavior.[2] Inferring expectations from observed behavior requires strong assumptions and might lead to circularity when the news shocks are used to test the same theory that was employed to infer expectations; see for example Blanchard, L'Huillier and Lorenzoni (2013). In contrast, the news shocks analyzed in this paper come from auxiliary data on bond prices, thus avoiding any circularity between the identification of the news and the estimated response to news.

[1] There is a large literature on consumption-based asset pricing; however, these theories impose restrictions on the joint distribution of asset returns and (aggregate) consumption, and do not separately test consumption behavior. Consumption theory is usually the starting point from which one derives implications for asset prices.

[2] Fuhrer (1988), Batchelor and Dua (1992), and Pistaferri (2001) rely on subjective survey expectations. Schmitt-Grohé and Uribe (2012) and Barsky and Sims (2012) infer news shocks from observed behavior, both of which use aggregate data.

Besides contributing to a large literature in public finance and asset pricing,[3] the application of the tax news shocks to household consumption also relates to a rich literature in macroeconomics. First, there has recently been a surge in studies analyzing the effects of expectation formation and news shocks on the economy.[4] While most of this literature is theoretical, this paper instead provides an empirical test for these theoretical predictions. Second, the household consumption response to news shocks is part of the broader study of household consumption behavior, which is one of the oldest and largest subjects in empirical economics.[5] The basic rational-expectations life-cycle theory of household consumption has two central implications: first, consumption should not respond to predictable income changes; second, consumption should respond approximately one-for-one to news about changes in after-tax lifetime income. There is a large and growing literature that tests the first implication of the rational-expectations life-cycle theory either by instrumenting for current income with variables known in advance or by using exogenous changes in predictable income provided by natural experiments.[6] This literature generally rejects the basic rational-expectations model by finding significant consumption responses to predictable income changes–that is, it finds that consumption is in fact excessively sensitive to predictable income changes. However, the results in this paper are not directly comparable with the excess sensitivity coefficients. The estimated response to predetermined cash-on-hand that is reported in these studies typically measures the response of consumption to one-time cash receipts either in real dollars or as a fraction of *current income*. In contrast, the estimates reported in this paper show the percentage change of consumption in response to a 1% change in expected *lifetime or "permanent" income*. Nonetheless, the results are related to the excess sensitivity literature, since they test the same model. If all households were current-income consumers, consumption should not respond to news but only to changes in current disposable income.

1 Tax Expectations from Municipal Yield Spreads

In order to measure fiscal foresight in the economy the econometrician needs to identify information sets that are at least as large as the ones used by the agents. This challenge goes back at least to Hansen, Roberds and Sargent (1991) and has recently been emphasized by Leeper, Walker and Yang (2013). I identify rational information sets using expectations that are based on asset

[3] E.g., Fama (1977), Poterba (1986), Kochin and Parks (1988), Green (1993), and Mankiw and Poterba (1996). The online appendix provides a more comprehensive overview of this literature.

[4] Recent research on expectation formation includes Mankiw and Reis (2002), Woodford (2002), Sims (2003), Barsky and Sims (2012), and Coibion and Gorodnichenko (2011). Research on news shocks includes Cochrane (1994), Beaudry and Portier (2006), and Jaimovich and Rebelo (2009). See Lorenzoni (2011) for a survey of this literature.

[5] Deaton (1992), Hayashi (1997), Attanasio (1999), and Jappelli and Pistaferri (2010) provide excellent surveys of this literature.

[6] Employing aggregate data, Campbell and Mankiw (1989) use an instrumental variables approach, while Poterba (1988) uses tax reforms as natural experiments. Another large segment of the literature uses cross-sectional variation in predictable income changes to test the first implication of the basic rational-expectations life-cycle theory; see for example, Shapiro and Slemrod (1995), Souleles (1999, 2002), Parker (1999), Shapiro and Slemrod (2003), Johnson, Parker and Souleles (2006), and Agarwal, Liu and Souleles (2007).

prices. Under informational efficiency asset prices aggregate information and reflect the largest public information set available at any given point in time. The yield spread between Treasury and municipal bonds reflects expected future tax rates because interest income from Treasury bonds is taxable while interest from municipal bonds is tax-exempt. At the same time, the yield spread also contains a premium to compensate for other factors such as liquidity risk and tax uncertainty.

In this section I derive the path of expected tax rates from relative spreads between Treasury and municipal bond yields. I discuss factors other than tax news that might affect the yield spread, and I provide strong evidence that the other main determinant of the spread is related to liquidity risk. Two independent pieces of data, the Flow of Funds and the Survey of Consumer Finances (SCF), provide suggestive evidence that the marginal investor is a household near the top of the income distribution. Furthermore, the marginal investor's position in the income distribution is stable over the sample period from 1977 to 2001, which is an important finding since it shows that changes in the yield spread reflect changes in expected future tax rates rather than movements across tax brackets by the marginal investor, holding fixed other risk factors. I use two natural experiments that provide additional variation at daily frequency to validate the tax news shocks and to assess the degree of foresight over a horizon of 1 to 30 years. Using these natural experiments I formally test the hypothesis that the marginal tax rate implied in the municipal yield spread is the personal income tax rate of an individual near the top of the income distribution. Finally, I extract the entire path of expected future tax rates at each point in time over the entire sample period from 1977 to 2001 using the identified marginal tax rate of the marginal investor to control for other risk factors.

1.1 Factors other than Expected Tax Rates

I use a novel data set of municipal bond yields at daily frequency from 1983 on and at weekly frequency since 1977, described in more detail in the online appendix. The municipal bond yields are based on an index of state bonds that have a AAA rating and are general obligations.[7] I use state bonds because of the higher liquidity compared to other types of municipal bonds; see for example Harris and Piwowar (2004). General-obligation bonds are backed by the full faith and credit of the issuing state, similar to the backing of Treasury bonds, and prime-grade general-obligation municipal bonds are therefore essentially free from default risk.[8] Moreover, municipal bonds in general and

[7] State bonds are a subset of all municipal bonds and benefit from the same federal tax exemption. There are differences between debt issued by states and local municipalities, and they relate mostly to the procedure in the case of a default. The 11$^{\text{th}}$ Amendment of the U.S. Constitution guarantees the sovereign status of a state. This implies that states cannot be sued and state property cannot be seized by investors without the consent of the state. The only exception where the Supreme Court accepted jurisdiction were suits between the federal government and a state (United States v. North Carolina, 1890) and between two states (South Dakota v. North Carolina, 1904); see English (1996). Therefore, there is no bankruptcy mechanism for U.S. states. Local municipalities in some states on the other hand can enter Chapter 9 of the Bankruptcy Code, which is similar to Chapter 11 for corporate defaults. For a more detailed discussion, see Ang and Longstaff (2013).

[8] The other main class of municipal bonds is revenue bonds. The credit worthiness of revenue bonds is tied to the underlying project that they finance. For instance, a state might issue a revenue bond to finance a new bridge, and the bridge might in turn generate revenue by collecting a toll. If the income from the toll falls short of the interest

general-obligation bonds in particular have a high recovery rate. For instance, Fitch Ratings assumes that general-obligation municipal bonds recover 100% of par within one year of default.[9] Since the Civil War no state has permanently defaulted on its general-obligation debt.[10] Hempel (1971) looks at the Great Depression, which is the most recent period with significant defaults on municipal debt. He shows that between 1929 and 1937 all outstanding municipal bonds–consisting mostly of debt of lower quality than general-obligation bonds–defaulted at an annual rate of 1.8%. However, 97% of the defaulted debt was eventually repaid. The last state to temporary default on its general obligations was Arkansas in 1933.[11] However, what matters for the yield spread is the credit risk *relative* to Treasury bonds. In this context it is important to note that although the U.S. has legally never defaulted on its debt, it changed the value of a U.S. dollar in terms of gold in the Gold Reserve Act of 1934. This of course is de facto a default, with bondholders suffering a real loss, while Arkansas' default in 1933 resulted 'only' in delayed repayment.[12]

State personal income taxes are another factor that might confound the relationship between the investor's marginal *federal* tax rate and the municipal yield spreads. While interest on municipal bonds is in general exempt from federal income taxes and interest on Treasury bonds is exempt from state and local income taxes, nothing prevents states from taxing interest on municipal bonds.[13] Table 1 shows that many states exempt municipal bond interest from state and local income taxes, either for all or at least for in-state investors, and several states do not collect personal income taxes at all. Moreover, investors have strong incentives to avoid paying state taxes on municipal bonds, for instance by investing in municipal bonds of their state of residence. Figure 1 compares the 10-year Treasury yield with 10-year municipal yields of four states, each of which taxes municipal interest differently. The four different tax treatments correspond to (almost) all possible combinations listed in Table 1.[14] With the exception of Illinois, all state bonds shown have a AAA rating and are general obligations. For Illinois there are no AAA general-obligation bonds available in the sample, so instead I use AA rated state bonds that are insured against default risk so that they are comparable to general-obligation bonds.[15] Figure 1 shows that the municipal yields are very

costs, the state might default on the revenue bond without defaulting on any other bond. This selective default is not possible with general-obligation bonds.

[9] Fitch Ratings, "Default Risk and Recovery Rates on U.S. Municipal Bonds," *Public Finance Special Report*, 2007.

[10] The online appendix compares the in-sample default rates between similarly rated corporate and municipal bonds. I show that the later have a much lower credit risk even conditional on the same credit rating. I also analyze whether there is evidence that rare default events affect the yield of AAA general-obligation state bonds, but do not find any.

[11] While there have been defaults of general-obligation bonds since the Civil War, the payment obligations were all satisfied later on. Arkansas eventually paid its general-obligation bondholders in full by 1943. In this sense there was no permanent default since the Civil War; see Hempel (1971). Almost all state bonds issued before the Civil War were revenue bonds, either to finance transportation projects and canals in the northern states or to finance banks in southern states; see English (1996).

[12] Reinhart and Rogoff (2011) for instance classify the Gold Reserve Act of 1934 as a default on U.S. federal debt.

[13] The exception is Tennessee, which taxes both municipal and Treasury interest income.

[14] The exception is again Tennessee for which I do not have historical municipal yield data.

[15] The main remaining difference in default risk between an insured and a general-obligation bond is counter-party risk, i.e. the risk that the insurer defaults at the same time as the insured municipal bond.

similar, in particular compared to the yield on Treasury bonds, despite the different tax treatment of municipal bond interest in the four states. This result strongly suggests both that state taxes are not as an important determinant of municipal yield spreads as federal taxes and that default risk is relatively small for highly rated general-obligation state bonds.[16] Furthermore, the small dispersion of AAA general-obligation municipal yields suggests that the relative liquidity shocks are common to all municipal bonds and have only a small idiosyncratic component. Taking an index of AAA general-obligation bonds further reduces the idiosyncratic component by averaging out any remaining idiosyncratic liquidity and state-specific shocks.[17]

1.2 A Model of Break-Even Tax Rates (BETR)

Interest income from Treasury bonds is exempt from state and local taxes, but is subject to federal income taxes, while interest on municipal bonds is exempt from federal income taxes. Moreover, as shown in Table 1, most states also exempt municipal bonds from state and local taxes, either for all investors or at least for in-state investors.

In order to interpret the yield data it is important to note that the relative municipal yield spread is different from the expected tax rate. Similarly, the yield spread between nominal and real Treasury bonds–the so-called break-even inflation rate–does not equal the expected rate of inflation. However, in both cases the yield spreads are related to the underlying expectations. To formalize this relationship I start with the definition of the par yield of a Treasury bond. Since Treasury bonds are taxed based on their imputed par yield, the par bond is the natural concept when analyzing the effects of taxes on bond prices, while zero coupon bonds are the starting point of most fixed-income models, which abstract from taxes.[18]

The yield $y^T_{t,m}$ on a Treasury bond maturing in m years and selling at par at date t is implicitly defined by[19]

$$1 = \sum_{s=1}^{m} \mathbb{E}_t[D_s(1-\tau_s)y^T_{t,m}] + \mathbb{E}_t[D_m]. \tag{1}$$

D_s is the stochastic discount factor of after-tax income s years ahead.[20] In order to satisfy equation

[16] State income taxes could significantly affect the municipal yield spread if the marginal investor lives in a state with high income tax rates and if her municipal bond interest income is taxable. The last two columns of Table 1 show maximum state income tax rates for 1977-2010. The reason for the small yield spread between the state bonds shown in Figure 1 is twofold. First, these states have relatively low top income tax rates in this period: 2.8% in Pennsylvania, 5.6%-5.95% in Massachusetts, 3% in Illinois, and 0% in Texas. Second, the fact that state taxes are deductible from federal taxable income further reduces the impact of state tax rates on the yield spread. Finally, bondholders seem to demand a slightly higher yields on Illinois bonds, consistent with the fact that Illinois taxes both in- and out-of-state municipal income.

[17] In a previous version of this paper I have calculated average state top income tax rates and checked whether my results are sensitive to the treatment of state income taxes. Since there is little variation in state income tax rates over my sample period, and since state income tax rates are lower that federal income taxes, I could not find any tangible effect of state income taxes on my results.

[18] Kueng (2012) provides a detailed overview of the tax treatment of bonds since 1970.

[19] To simplify notation I abstract here from the fact that coupon payments are semi-annual rather than annual, but I take this into account when analyzing the data.

[20] A word on notation: Whenever possible I use the first subscript–usually t–to denote calendar or "household

(1), the Treasury par yield y^T needs to increase in response to an increase in expected future tax rates $\mathbb{E}_t\tau_s$, holding fixed the discount factor D.

In practice, factors other than taxes influence the municipal yield spread, and the discussion above suggests that these factors are mainly related to liquidity. To minimize the effect of liquidity shocks on the yield spread I use off-the-run Treasury bonds which are less liquid than on-the-run issues and are therefore more similar to municipal bonds, and I use state bonds which are the most liquid municipal bonds. However, the off-the-run Treasury bond market is still much more liquid than the most liquid municipal bond market.[21] To account for any remaining risk factors other than taxes I introduce a latent stochastic shock λ for holding municipal bonds. The par yield $y^{\mathcal{M}}_{t,m}$ of a similar tax-exempt municipal bond is given by

$$1 = \sum_{s=1}^{m} \mathbb{E}_t[D_s(y^{\mathcal{M}}_{t,m} - \lambda_{s,m})] + \mathbb{E}_t[D_m]. \tag{2}$$

To satisfy equation (2), the municipal par yield $y^{\mathcal{M}}$ has to increase to compensate a positive liquidity shock λ, holding fixed the discount factor D.[22,23]

The marginal investor is indifferent between investing one more dollar in a Treasury or a municipal bond with the same maturity. Let M be the longest maturity available. I solve (1) and (2) as a function of the relative municipal yield spread $y^{\mathcal{M}}/y^T$ to obtain[24]

$$\theta_{t,m} \equiv 1 - \frac{y^{\mathcal{M}}_{t,m}}{y^T_{t,m}} = \sum_{s=1}^{m} \underbrace{\frac{\mathbb{E}_t D_s}{\sum_{i=1}^{m} \mathbb{E}_t D_i}}_{w^{(m)}_{t,s}} \cdot \mathbb{E}_t\tau_s - \underbrace{\frac{\sum_{s=1}^{m} \mathbb{E}_t D_s \lambda_{s,m}}{y^T_{t,m} \sum_{i=1}^{m} \mathbb{E}_t D_i}}_{\Lambda^{\lambda}_{t,m}} + \underbrace{\frac{\sum_{s=1}^{m} \mathbb{C}\mathrm{ov}_t(D_s, \tau_s)}{\sum_{i=1}^{m} \mathbb{E}_t D_i}}_{\Lambda^{\tau}_{t,m}}, \tag{3}$$

which can be written in vector form as $\theta_{t,m} = w^{(m)\prime}_t \, \mathbb{E}_t\tau - \Lambda^{(m)}_t$. The sum of the liquidity premium Λ^{λ} and the tax risk premium Λ^{τ} is $\Lambda^{(m)}_t = \Lambda^{\lambda}_{t,m} - \Lambda^{\tau}_{t,m}$. The expected tax path over the horizon M is given by the vector $\mathbb{E}_t\tau = (\mathbb{E}_t\tau_1 \ldots \ \mathbb{E}_t\tau_M)'$.[25] $w^{(m)}_t = (w^{(m)}_{t,1} \ldots \ w^{(m)}_{t,m} \ 0 \ldots 0)'$ is the vector of

time" and the second subscript–usually m or s–to denote the forecast horizon in years. For example, $y^T_{t,m}$ is the yield at date t (today) on a Treasury bond that matures in m years. For bond yields, calendar time t is daily or weekly before or after 1983, respectively. "Household time" t in the CEX is quarterly such that $\Delta_t x_t$ is the quarterly change of x_t. However, since the CEX is a *monthly rotating panel*, the overall sampling frequency of the consumption data is monthly.

[21] Treasury bonds that are issued before the most recently issued bond of a particular maturity are called *off-the-run*, while the most recently issued bond is called *on-the-run*.

[22] I add the liquidity shocks in a linear way to obtain an analytical expression that is linear in both the path of expected tax rates as well as the liquidity premium; see equation (3) below. Adding the liquidity shock in a multiplicative way does not change the conclusions of this paper.

[23] In an ideal setting we would have two identical bonds with the exception that one is taxable and the other is tax-exempt. $y^{\mathcal{M}} - \lambda$ is the risk-adjusted municipal yield that proxies for such an ideal but unobserved tax-exempt Treasury bond.

[24] Equating (1) and (2) implicitly assumes that both bonds are held to maturity, thereby abstracting from the timing of capital gains and losses; see for example Constantinides and Ingersoll (1984) and Green (1993). However, unexpected capital gains on both municipal and Treasury bonds are taxable at the capital gains tax rate; see Kueng (2012). Therefore, the yield spread between the two bonds cancels out any first-order effects of capital gains taxes.

[25] When I calculate the weights in the empirical section below I take into account that coupon payments are

annuity weights such that $w_t^{(m)\prime}\mathbb{E}_t\tau = \sum_{s=1}^{m} w_{t,s}^{(m)}\mathbb{E}_t\tau_s$ is the annuity value of the path of expected tax rates over the maturity m of the two bonds.[26]

In analogy to the break-even inflation rate I call θ the *break-even tax rate* (BETR). If there were no uncertainty and if taxes were constant over the maturity of the two bonds then the break-even tax rate equals the marginal tax rate of the marginal investor, i.e. $\theta_{t,m} = \tau$. If one allows for uncertainty about future tax rates and liquidity risk then the relationship between expected tax rates and break-even tax rates becomes more complicated. Equation (3) reveals that the BETR is in general a weighted average of expected future tax rates over the maturity of the bonds minus a premium Λ. Since the market for Treasuries is more liquid than the municipal bond market, and because liquidity demand is high in bad times, the liquidity premium Λ^λ is likely non-negative on average.

Marginal income tax rates are low in bad times because of the progressivity of the income tax and the possibility of countercyclical tax policies. After an extensive analysis of the narratives surrounding all major post-war tax changes, Romer and Romer (2010) conclude that all income tax changes from 1980 to 2001–with one minor exception in 2001–are not countercyclical policies or spending related but motivated by concerns about the long-run growth rate or the federal debt. Hence, the tax risk premium Λ^τ is likely primarily due to the progressivity of the income tax over the period 1977-2001. The progressivity induces an insurance mechanism by paying larger after-tax interest in bad times and lower after-tax income in good times. The tax premium is therefore likely non-positive.[27]

Stacking equation (3) for the entire term structure of length M I obtain a system of equations that provides a mapping between the M break-even tax rates θ_t and the underlying path of expected forward tax rates $\mathbb{E}_t\tau$ over the forecasting horizon of 1 to M years at any point in time t,

$$\theta_t = W_t\ \mathbb{E}_t\tau - \Lambda_t. \tag{4}$$

W_t is the M-by-M lower triangular annuity weighting matrix $[w_t^{(1)} \ldots\ w_t^{(M)}]'$ and the vector of risk premia is given by $\Lambda_t = (\Lambda_t^{(1)} \ldots\ \Lambda_t^{(M)})'$.

semi-annual and use $\mathbb{E}_t[D_s] = (1 + y_{t,s}^{\mathcal{M}}/2)^{-2s}$.

[26] In the absence of discounting, the first m elements of $w_t^{(m)}$ are equal to $1/m$. With discounting, the weights are generally decreasing in m such that $w_{t,m}^{(m)} < 1/m$. If the tax-exempt yield curve steepens, then future income is discounted more heavily, leading the weights on future tax rates to decrease.

[27] To quantify Λ^τ I estimate the following population moments: $\min_s\{\mathbb{C}\mathrm{ov}(D_s,\tau)\}$, $\max_s\{\mathbb{C}\mathrm{ov}(D_s,\tau)\}$, and $\sum_s \mathbb{E}_t D_s$. The estimates are -0.0013, 0.00128, and 13.80, the latter with a standard deviation of 2.02. Since Λ^τ is only of order 1/1000, this calculation suggests that the tax risk premium is non-positive and negligible. However, this is only suggestive since I use the current yields to calculate D_s. For a recent study that separately estimates the liquidity and tax uncertainty premium, see Longstaff (2011). In this paper I do not attempt to separate these two risk factors, and I refer to them jointly as the (liquidity) risk premium.

1.3 The Marginal Tax Rate of the Marginal Investor

In order to recover the underlying path of expected tax rates $\mathbb{E}_t\tau$ one needs to know the marginal tax rate of the marginal investor and correct for the risk premium Λ_t. Figure 2 contrasts the 2- and the 15-year BETR–both the raw data and the trend component after applying a low-pass filter–with the marginal tax rate of the top 1% of the income distribution, taken from Saez (2004).[28] The 2-year BETR follows the top marginal tax rate closely, with the exception of the early 1990s, suggesting that the marginal investor is a household in the top of the income distribution. This finding is consistent with the fact that incentives to hold tax-exempt debt increase with the effective marginal tax rate. Importantly, movements in the 2-year BETR anticipate movements in the top rate. The 15-year BETR, which averages expected future tax rates over a longer horizon, behaves differently. It sharply decreases during the early 1980s in anticipation of the Reagan tax cuts and stays relatively constant until the late 1990s when it starts to decline again in anticipation of the Bush tax cuts of the early 2000s. The fact that the time series of BETRs with different maturities do not move one-for-one strongly suggests that the bond market not only forecasts the timing of future income tax changes but also the *expected path* of tax rates. Therefore, bond prices determine not only the *expected timing* of future tax changes but also the *expected persistence* of such shocks.

For the analysis of the response of household consumption to tax news in the next section it is important to identify the entire path of expected tax rates $\mathbb{E}_t\tau$ from the term structure of break-even tax rates θ_t. According to the basic rational-expectations life-cycle model, consumption should respond to changes in the expected after-tax lifetime income. In particular, two tax reforms that affect the expected after-tax lifetime income by the same amount should have the same effect on current consumption independent of the timing of the tax changes (abstracting from liquidity constraints and precautionary saving). In order to compute the expected after-tax lifetime income one needs to identify the entire path of expected future tax rates.

Figure 2 also shows that the 2-year and the 15-year break-even tax rates are generally below the top marginal tax rate reflecting the existence of a positive risk premium Λ_t.[29] The risk premium appears to be larger for the 15-year than the 2-year BETR, causing the 15-year BETR to be below the 2-year BETR which in turn is below the realized tax rate. The finding that the relative risk premium increases with the maturity of the yield spread is consistent with a large literature on the so-called "muni puzzle," the observation that the slope of the municipal bond yield curve is almost always steeper than the slope of the Treasury yield curve. There is a large literature in finance that tries to explain this fact; see for example, Fama (1977), Poterba (1986), Green (1993), Park (1995), and Mankiw and Poterba (1996). So far, no single explanation of this puzzle has emerged, although some factors have been rules out, such as default risk as well as systematic risk and duration risk;

[28] Saez (2004) uses annual tax return data from the Internal Revenue Service (IRS). I transform Saez's annual tax series to monthly frequency using the months at which withholding tables change as turning points. The only exception is OBRA 1993 (discussed below) that was introduced retroactively. In this case I use the date at which the bill was signed into law by President Clinton.

[29] Figure 1 in the online appendix shows the average break-even tax rate risk premium $\mathbb{E}[\Lambda_t]$ as a function of the maturity m. I calculate the premium using equation (7) derived below.

see Chalmers (1998, 2006). The main remaining explanations are taxes and liquidity. This paper shows that taxes can explain much of the variation of yield spread, at least at lower frequencies. Whether tax uncertainty or liquidity risk can account for the remaining difference–especially at high frequencies–is an interesting question for future research.

Figure 2 suggests that the simple model of the BETR given by equation (3) fits the data well. To provide further evidence on the identity of the marginal investor I turn to two additional data sources. Using the Federal Reserve's Flow of Funds Accounts, Ang, Bhansali and Xing (2010) show the evolution of municipal debt ownership since 1950.[30] Households' ownership, either direct or indirect via mutual funds, increases starting in the 1970s. This change in ownership can partly be explained by the emergence of mutual funds which facilitate investment in municipal bonds considerably. The decline of bank ownership of municipal debt mirrors the rise in household ownership and is partly explained by legislative actions limiting the tax-exemption of municipal debt for corporations and by changes in regulations of bank charters in many states. The share held by insurance companies and other institutions, including foreign investors, is low and remains roughly constant. The changing pattern of municipal bond ownership might explain the conflicting evidence found in the earlier literature that tries to identify which marginal tax rate is implied in the municipal yield spread; see for example Fama (1977), Poterba (1986), Green (1993), and Park (1995). The important point for this paper is that the data from the Flow of Funds suggests that starting in the 1970s households are the marginal investors in municipal and Treasury bonds.

Next, one needs to know which households own municipal bonds in order to determine the marginal tax rate identified by the relative bond spread. Since equations (1) and (2) are first-order conditions of the marginal investor's portfolio choice problem, they should apply to all households holding both types of bonds. To analyze this claim I map the SCF to the NBER TAXSIM calculator and impute effective marginal tax rates for each household.[31] I define the marginal tax rate of the marginal investor as the asset-weighted average of the effective marginal tax rate over all households that own both taxable and tax-exempt bonds. Figure 3 compares the estimates of the marginal investor's marginal tax rate with the marginal tax rates of different percentiles of the income distribution taken from Saez (2004). The imputed tax rates in the SCF are very similar to the (risk-adjusted) short-run break-even tax rates derived from the municipal yield spreads. The marginal tax rate of the marginal investor identified in the SCF is close to the tax rate of the top 1% and above the marginal tax rate of the top 5% to 1% of the income distribution.[32] Since the top two tax brackets move very closely during my sample period it is not important whether the marginal investor is in fact in the top bracket or one bracket below that. The identification of the consumption response to tax news shocks in the next section relies on *changes* in the path of expected tax rates, not the level. Therefore, choosing the wrong level of the marginal investor's tax

[30] The online appendix contains the corresponding figure from their analysis.

[31] See Feenberg and Coutts (1993).

[32] Using data from federal income tax returns in 1988, Feenberg and Poterba (1991) find similar marginal tax rates for households that report receiving tax-exempt interest income.

rate does not affect the results as long as this tax rate moves closely with the true tax rate.[33]

In sum, the preceding analysis demonstrates that the position of the marginal investor in the income distribution remains stable during the sample period. Hence changes in break-even tax rates, holding fixed the risk premium, are due to changes in the effective tax rate of the marginal investor and not due to the marginal investor changing her position in the income distribution holding tax rates fixed.

1.4 Two Presidential Elections as Natural Experiments

The asset allocation data as well as the relative bond prices both strongly suggest that the marginal investor is a household in the upper tail of the income distribution. However, these findings are only suggestive about the marginal investor's identity without modeling the link between the portfolio allocation and equilibrium asset prices, which is beyond the scope of this paper. Instead, I use two natural experiments to formally test the hypothesis that the marginal investor is a household near the top of the income distribution. Furthermore, I asses the degree to which bond markets predict the evolution of future tax rates. The presidential elections of 1992 and 2000 are close to ideal natural experiments for this purpose.[34] During both elections the nominees from the Democratic and the Republican Party campaigned on very different proposals concerning the top income tax rates. Furthermore, these tax proposals received extensive coverage by the media and featured prominently in both the primary and presidential debates.[35] In 1992 Bill Clinton proposed to increase the top tax rate by 10% to deal with the high level of government debt. His victory ultimately lead to the Omnibus Budget Reconciliation Act (OBRA 1993), which increased the top rate by 8.6% retroactively back to January 1, 1993. Importantly, OBRA 1993 left the dividend and the long-term capital gains tax rates unchanged.[36] President George H.W. Bush, haunted having

[33] The point estimates of the marginal investor's marginal income tax rate are precise except for 1994. The larger standard errors in 1994 probably reflect the fact that the tax increase introduced in August 1993 was *retroactive* back to January 1, 1993 (OBRA 1993). Heterogeneity in portfolio re-balancing of marginal bond investors might explain these larger standard errors.

[34] Other studies that looked at the impact of elections on the bond markets include Slemrod and Greimel (1999) and Ayers, Cloyd and Robinson (2005). Slemrod and Greimel (1999) find that changes in the election probability of Steve Forbes in 1996, who proposed to introduce a flat tax, had an impact on the municipal yield spread of maturities 5 and 10 years but not for the 30-year maturity. Ayers et al. (2005) also use election probabilities from 1992 and find a positive response of the break-even tax rates using maturities 5, 10, and 30 years. Interestingly, they also find negative excess returns on dividend-yielding stocks in response to changes in the election probability of Bill Clinton. My results are an extension of their analysis. I use the entire term structure of BETRs and I offer a quantitative interpretation of the regression coefficients. Moreover, I extract the path of expected forward tax rates from the vector of regression coefficients.

[35] For a comparison of the campaign proposals, see Seib and Murray (1992) and Calmes (2000).

[36] OBRA 1993 also increased the top corporate tax rates, but only by 1% from 34% to 35%. George H.W. Bush proposed to cut long-term capital gains tax rates from 31% to 15.4%. Clinton on the other hand planned to leave the rates unchanged but offered to exclude 50% of long-term capital gains from taxation; see Seib and Murray (1992). Therefore, the presidential election of 1992 is useful to test the importance of the corporate tax rate against the income tax rate as a determinant of the municipal yield spread. However, the election of 1992 is not fully suited to discriminate between income taxes and taxes on long-term capital gains. Fortunately, the presidential election of 2000 allows me to discriminate between these two tax rates.

broken his tax pledge from the 1988 election campaign, promised not to raise any taxes.[37]

Similarly, during the presidential election of 2000 George W. Bush proposed to cut taxes across the board–including the top rate–by about 5%, using the budget surplus that accumulated under President Clinton.[38] Incumbent Vice President Al Gore proposed tax breaks for low and middle income taxpayers while leaving the top rates unchanged. Bush's victory in 2000 ultimately lead to the Economic Growth and Tax Relief Reconciliation Act of 2001 (EGTRRA) and the Jobs and Growth Tax Relief Reconciliation Act of 2003 (JGTRRA) which lowered the top income tax rate by 4.6% over three years. Importantly, EGTRRA 2001 leaves the top corporate income, capital gains, and dividend tax rates unchanged.[39]

In this exercise I use data from the Iowa Electronic Markets (IEM), a political prediction market described in more detail in the online appendix. The IEM provides the daily price of a winner-takes-all contract during the last few month of the presidential races of 1992 and 2000. Those contracts pay \$1 if the specific candidate wins and \$0 otherwise. Since bets are limited to \$500, market participants cannot use the prediction markets to hedge their income tax risk. Changes in the prices of such contracts can be interpreted as measuring daily changes in the election probability of the presidential candidates.[40] In the following derivation of the regression equations I use the presidential election of 2000, but the same applies for the election of 1992 substituting "Clinton" for "Bush" and "Bush" for "Gore".

Let p_t be the price of a contract that pays \$1 if George W. Bush wins the election in 2000 and 0 otherwise. $\mathbb{P}\mathrm{r}_t(\mathrm{Bush})$ denotes the probability of Bush winning the election conditional on all information available at time t. I assume that the price corresponds to the rational conditional probability measure, i.e. $p_t = \mathbb{P}\mathrm{r}_t(\mathrm{Bush})$. Using the law of iterated expectations, I decompose the conditional expectation of the path of future tax rates $\mathbb{E}_t\tau$ as $\mathbb{E}_t\tau = p_t \cdot (\mathbb{E}_t[\tau|\mathrm{Bush}] - \mathbb{E}_t[\tau|\mathrm{Gore}]) + \mathbb{E}_t[\tau|\mathrm{Gore}]$. Substituting in (4) I obtain a system of 30 regression equations

$$\begin{aligned} \theta_t &= p_t \cdot W_t(\mathbb{E}_t[\tau|\mathrm{Bush}] - \mathbb{E}_t[\tau|\mathrm{Gore}]) + (W_t\mathbb{E}_t[\tau|\mathrm{Gore}] - \Lambda_t) \\ &= p_t \cdot \beta + (\alpha + Z_t\Gamma + \varepsilon_t)\,, \end{aligned} \tag{5}$$

where α are maturity fixed effects and Z_t is a list of variables that capture risk premium shocks

[37] In a speech at the 1988 Republican National Convention as he accepted the nomination, George H.W. Bush used the (in)famous phrase "Read my lips: no new taxes". In 1990 and under pressure from a Democratic congress he signed the Omnibus Budget Tax Reconciliation Act (OBRA 1990) which went into effect on January 1, 1991.

[38] Specifically, Bush proposed to cut the top rate from 39.6% to 33%.

[39] Later in his first term, President George W. Bush lowered the dividend tax rates and the long-term capital gains tax rates to 15%, 5%, and 0% (JGTRRA 2003). However, these cuts were not part of his campaign platform; see Calmes (2000). The presidential election of 2000 can therefore be used to test the impact of the top income tax rate on the municipal yield spreads against all other marginal tax rates.

[40] See Snowberg, Wolfers and Zitzewitz (2011) for a more extensive discussion of the use of prediction markets for economic inference.

Λ_t.[41] Model (4) delivers the interpretation of the population parameters to be estimated,

$$\beta = \mathbb{E}[W_t]\ (\mathbb{E}_t[\tau|\text{Bush}] - \mathbb{E}_t[\tau|\text{Gore}]). \tag{6}$$

$\mathbb{E}[\cdot]$ without a subscript is defined as the average of the conditional expectations over the election sample, i.e. $\mathbb{E}[x] \equiv \frac{1}{T}\sum_{t=1}^{T}\mathbb{E}_t[x]$.[42] Equation (6) shows that the vector of population regressions β contains the annuity values of the difference in the paths of expected tax rates ($\mathbb{E}_t[\tau|\text{Bush}] - \mathbb{E}_t[\tau|\text{Gore}]$) between a world in which Bush wins the election in 2000 and the counter-factual world in which Gore wins. Table 2 lists the estimated response $\hat{\beta}$ of the BETRs to changes in the election probability in 2000 and 1992 for the eight most commonly traded maturities. Most coefficients are statistically significantly different from zero and have the expected sign.

To interpret the magnitudes of the estimated coefficients, note that the contracts pay 100 cents if the candidate wins and zero otherwise. Therefore, an increase of the price by 1 cent corresponds to a 1% increase in the perceived probability of the candidate winning the presidential election. Multiplying the coefficients by 100 yields the predicted change in the BETRs if George W. Bush (Clinton) wins the election in 2000 (1992) relative to the counter-factual that Gore (George H.W. Bush) wins. Figure 4 and Figure 5 plot the vector of all 30 regression coefficients, all multiplied by a hundred. Letting $\tau_t^{pf} = (\tau_{t,1} \ldots\ \tau_{t,M})'$ denote the perfect-foresight path of realized tax rates at date t over the horizon of 1 to $M = 30$ years, I calculate the hypothetical regression coefficients one should obtain under perfect foresight, $\beta^{pf} = \mathbb{E}[W_t](\tau_t^{pf} - \tau_t)$. Here I assume that the level of the unobserved counter-factual tax path–$\mathbb{E}_t[\tau|\text{Gore}]$ in 2000 and $\mathbb{E}_t[\tau|\text{H.Bush}]$ in 1992 which is not identified by the regression–is the status quo tax rate during the election year, i.e. $\tau_t = 39\%$ in 2000 and $\tau_t = 31\%$ in 1992, respectively. I show two scenarios for the tax path of future tax rates beyond 2011, one in which the Bush tax cuts expire in 2011 as scheduled and one in which they become permanent.

Figure 4 and Figure 5 show the path of expected break-even tax rate changes $\hat{\beta}$ together with the change in the break-even tax rates under perfect foresight β^{pf}. Note that the regression does not impose any restrictions on the sign, size, or the shape of the estimated path. While the estimates are somewhat less precise for short maturities, the coefficients for the entire term structure of BETRs show a strong relationship between the estimated path of expected BETR changes and the perfect-foresight change in the BETRs. I conclude that the municipal yield spread is strongly driven by expected future top income tax rates.

[41] I include in this list among other variables the yield spread between off- and on-the-run Treasuries, between corporate and Treasury bonds, between Aa and pre-refunded municipal bonds, the credit spread between Baa and Aa municipal bonds, the 30-day visible municipal bond supply, and the trading volume in the prediction market. The online appendix provides the full set of regression results for the eight most commonly traded maturities.

[42] I searched the archives of *The New York Times* and *The Wall Street Journal* for articles that would indicate a change in the tax proposal of the candidates during the sample period but did not find any. Hence I assume that the relative difference between the tax proposals ($\mathbb{E}_t[\tau|\text{Bush}] - \mathbb{E}_t[\tau|\text{Gore}]$) remains constant during the final months of the election, i.e. $\mathbb{E}_t[\tau|\text{Bush}] - \mathbb{E}_t[\tau|\text{Gore}] = \mathbb{E}[\tau|\text{Bush}] - \mathbb{E}[\tau|\text{Gore}]\ \forall\ t$. Otherwise, β identifies the average value of the relative difference between the two proposals during the final months of the presidential election, i.e. $\beta = \mathbb{E}\left[W_t(\mathbb{E}_t[\tau|\text{Bush}] - \mathbb{E}_t[\tau|\text{Gore}])\right]$.

1.5 Deriving Expected Tax Rates from Break-Even Tax Rates

I am ultimately interested in the inverse mapping of equations (4) and (6), i.e. $\mathbb{E}_t\tau$ as a function of θ_t and $\mathbb{E}[\tau|\text{Bush}] - \mathbb{E}[\tau|\text{Gore}]$ as a function of β. These market-based expected tax rates can be interpreted as *forward tax rates* in analogy to forward interest rates derived from the term structure of spot rates. Recall that W_t is a lower triangular annuity matrix with its last column vector given by $(0\ldots0\ w_{t,M}^{(M)})'$. In the data, $w_{t,M}^{(M)}$ has a mean of 0.01 with a standard deviation of 0.003 and a minimum of 0.003, so W_t can be close to singular. Inverting this matrix makes the solution sensitive to small perturbations of β or θ_t that are unrelated to tax news. Instead of a direct inverse I use a robust inverse of W_t, know as a first-order ridge regression in the statistics literature.[43] I impose that the expected tax path is a smooth function across maturities $m = 1, \ldots, 30$, since it is implausible that the expected tax rate e.g. in 20 years is very different from the expected tax rate in 19 or 21 years. The robust inverse penalizes such non-smooth solutions with a factor μ, called the regularization parameter. The online appendix shows that the parameter μ only significantly affects long-run expectations and discuss how to optimally choose μ.

Figure 6 shows the path of expected tax rates during the presidential election of 2000 obtained by inverting the regression coefficients $\hat{\beta}$. The top tax rate is expected to decrease to 35% by the year 2002 and to return quickly back to the initial level of 39.6%. Moreover, the bond markets expect the initial tax cuts to be off-set by later tax increases above the initial level of 39.6%. One interpretation is that the bond markets expect the tax cuts to be unsustainable. Compared to the perfect-foresight tax path, the path of the expected tax rates returns quickly back to rates around 40%. The expected tax rate starts to increase sharply after four years. One interpretation of this behavior is that the bond markets expect President George W. Bush to serve for only one term. Turning to the presidential election of 1992, Figure 7 graphs the path of expected tax rates against the perfect-foresight path. The bond markets correctly anticipate the new level of the top tax rate induced by the Clinton tax increase in 1993. The path of expected tax rates slightly underestimates the duration of the Clinton tax increase. The path also shows that the bond markets in 1992 expect the long-run tax rates to return back to the initial level. However, the tax cuts enacted under President W. Bush "only" lowered the top rate to 35% instead of 31%, the level in 1992, or 33%, George W. Bush's initial campaign proposal.

It is remarkable that the results from both elections suggest that both tax reforms were expected to be temporary. In both cases, the long run tax rates eventually return back to the initial levels of the election year.[44] In the next section I have to make an assumption about the perfect-foresight path of tax rates beyond 2011. Consistent with the regression results from the presidential election of 2000 I assume that from 2011 on the expected tax rate reverts back to the Clinton level.

[43] The word *regression* can be misleading in this context since I do not perform statistical inference in the traditional sense of projecting a vector from a larger onto a smaller space. Instead, the first-order ridge "regression" calculates M forward tax rates $\mathbb{E}_t\tau$ from M observed break-even tax rates θ_t. The constraint on the first-derivative of the solution is matched by the additional regularization penalty parameter μ. See the online appendix for more details.

[44] More precisely, in the long run the tax rates return back to the unobserved counter-factual expected tax path $\mathbb{E}[\tau|\text{Gore}]$ respectively $\mathbb{E}[\tau|\text{H.Bush}]$ which might be different than the top tax rate in the election year.

The two natural experiments show that the model of the BETRs given by equation (4) is an accurate description of the relative municipal yield spread. They also show that the expected tax rates that underlie the BETRs forecast future top tax rates surprisingly well. The experiments highlight the necessity of imposing some restrictions on the solution to the inverse problem in order to obtain a smooth and hence reasonable path of expected forward tax rates.

Unfortunately, the additional source of variation provided by the election probabilities is not available for the entire sample period. Instead, I impose two identifying assumptions to recover $\mathbb{E}_t\tau$ from θ_t during the sample period from 1977 to 2001. The first assumption requires that the bond spreads reflect rational-expectations,

$$\mathbb{E}[\underbrace{W_t(\mathbb{E}_t\tau - \tau_t^{pf})}_{\text{BETR forecast error}}] = 0 \ . \tag{7}$$

Equation (7) requires that the BETR forecast error is unbiased. The time series of the BETRs (Figure 2), the Flow of Funds, the SCF (Figure 3), and especially the two natural experiments (Figures 4, 5, 6, and 7) all show that the marginal tax rate of the top 1% of the income distribution is the tax parameter that determines the municipal yield spreads (in the absence of any shocks to the relative risk premium).Rearranging (4) and imposing (7) yields a measure of the average risk premium, $\mathbb{E}[\Lambda_t] = \mathbb{E}[W_t\tau_t^{pf} - \theta_t]$. Figure 1 in the online appendix shows the average risk premium as a function of the maturity m, estimated globally over the entire sample from 1977 to 2001. Consistent with the muni puzzle, the average risk premium is monotonically increasing in the maturity of the BETR.

The second identification assumption deals with temporary shocks to the risk premium. Adding $\mathbb{E}[\Lambda_t]$ to θ_t only adjusts the level of the BETR series but does not deal with shocks to the risk premium.[45] I assume that households and the marginal investors form tax expectations independently of the municipal yield spread.[46] For instance, households read newspapers or follow political campaigns and use all these sources of information to form expectations about future tax rates. The econometrician does not directly observe those news sources, but can infer the aggregate information set by looking at municipal yield spreads and interpret the data through the lens of the BETR model, equation (4). For instance, suppose the break-even tax rates decrease at date t but immediately rebound the next day, at $t + 1$. The econometrician can use this fact to estimate the tax expectations at date t. He will conclude that this change in break-even tax rates was most likely due to say a liquidity shock instead of tax news. If he uses only past and current prices he will underestimate the rational information set. This way of modeling tax news implies that the econometrician wants to use all prices–past, current, and future–to infer the path of expected tax rates $\mathbb{E}_t\tau$ at any point in time.

Filtering the tax news shocks from the "noise" shocks–i.e. the risk premium shocks–is important

[45] Ignoring the average risk premium would lead one to falsely infer a much lower marginal tax rate than the top income tax rate.

[46] I do not assume that all rich households in the CEX are marginal municipal bond investors. Instead, the marginal investors are a subset of all rich households.

since the tax news shocks form the regressor in the consumption analysis in Section 2. Liquidity shocks introduce noise and therefore potentially attenuation bias of the consumption response coefficient. This attenuation bias toward zero would lead to the conclusion that households do not respond to news even if they in fact behave according to the rational-expectations life-cycle model. To obtain a more precise measure of the expected tax rates I use a two-sided low-pass filter that passes all frequencies below two years. While the filter may remove some tax news shocks in addition to liquidity shocks, it reduces potential attenuation bias in the analysis of household consumption. The two-year low pass filter is motivated by the fact that two years is the shortest period between two income tax reforms in the sample (OBRA 1990 and OBRA 1993).[47] I denote the low-frequency component of the BETR by $\tilde{\theta}_t$; Figure 2 shows θ_t and $\tilde{\theta}_t$ for 2- and 15-year maturities.[48]

With these two identification assumptions–that there is no systematic forecast error, and that the expected tax rates affect the trend component of the BETR series while high-frequency fluctuations reflect noise–I recover the underlying path of expected future tax rates $\mathbb{E}_t\tau$ using a first-order ridge regression; see the online appendix.[49]

Figure 8 shows the path of expected tax rates $\mathbb{E}_t\tau$ at the beginning of each year against the perfect-foresight tax path τ_t^{pf} for each month of January from 1977 to 1982.[50] While Figure 2 already suggests that the Reagan tax cuts were well anticipated, this is only a conjecture since the time series shown in Figure 2 are break-even tax rates θ_t and not forward tax rates $\mathbb{E}_t\tau$. The path of expected forward tax rates in Figure 8 obtained by inverting the break-even tax rates of all available maturities confirms this conjecture.[51] The sequence shows that taxes are expected to remain high during Jimmy Carter's presidency and to even increase over the foreseeable future.[52] The long-run

[47] I checked my results using other frequency cut-offs but did not find any tangible effects on the results. The two year cut-off is conservative since it probably filters out some tax news shocks. This loss of information lowers the precision of the consumption response estimates. On the other hand, this cut-off value lowers the level of noise in the tax news shocks. The reduction of the noise reduces the potential attenuation bias in the consumption response coefficients. Therefore, the choice of the frequency cut-off reflects a trade-off between bias and efficiency of the estimates. Note that noise biases the consumption response towards zero and hence against finding an effect of tax news shock on household consumption.

[48] The robustness section below analyzes the effect of different filters.

[49] Finally, before I combine the tax shock with the household consumption data I normalize the level of the expected tax rate such that the one-year expected tax $\mathbb{E}_t\tau_1$ rate is zero. By using this normalization I assume that permanent tax shocks which move all BETRs in the same direction by the same amount have to be anticipated at least one year in advance. Fundamental tax reforms such as TRA 1986 for example are usually discussed years in advance before they pass Congress. Hence, if an unanticipated permanent shock to all BETRs occurs, then I assume that it is related to changes in the liquidity premium. The purpose of this normalization is to further reduce measurement error and potential attenuation bias towards zero in the consumption response coefficients. All the identifying variation then comes from changes in the BETRs *relative* to each other, that is from the cross-section (i.e. the term structure) of municipal yield spreads.

[50] The forecast horizon for this period is 15 years because Treasury yields are not available at longer maturities before 1983.

[51] The web appendix of this paper (https://sites.google.com/site/lorenzkueng/) contains a video of the evolution of $\mathbb{E}_t[\tau]$ from January 1977 to August 1982 that shows monthly changes in the path of expected tax rates over a 15-year forecasting horizon.

[52] The initial increase in expected tax rates reflects proposals during the late 1970s by President Carter to raise top income tax rates; see Poterba (1986). The increase is also consistent with expected bracket creep due to rampant inflation during this time and that the tax brackets were not yet indexed to inflation. Since the marginal tax rate of the marginal investor was well below the top statutory rate, expected increases in nominal income would push

expectations decreased sharply during the presidential election of 1980 as it became increasingly clear that Ronald Reagan would become the next president. Between 1980 and 1982 as Reagan passed his first tax cut–the Economic Recovery Tax Act (ERTA 1981)–the bond market also started to anticipate the second tax reform, the Tax Reform Act of 1986 (TRA 1986). This figure reveals an astonishing degree of fiscal foresight contained in the municipal yield spreads. In the next section I use changes in the paths of expected tax rates to estimate the household consumption response to tax news.

In sum, the time series of market-based expectations derived in this section shows that fiscal foresight can be considerable. Moreover, the path of expected tax rates $\mathbb{E}_t\tau$ derived from municipal yield spreads does a good job of recovering the underlying rational tax expectations. While the wealthy households that invest in municipal bonds have a high degree of fiscal foresight, their expectations may not be representative of consumers as a whole. In the next section I quantify the degree of fiscal foresight of households by estimating the response of household consumption to tax news in order to learn more about consumer behavior and the transmission of tax news shocks in the real economy.

2 Household Consumption Response to Tax News

To demonstrate the usefulness of the identified expected tax rates derived in the previous section, I study the response of household consumption to news about future taxes in the context of a rational-expectations life-cycle model. To map the tax news shock to the household's consumption problem and to interpret the estimated consumption response I use the permanent income model with certainty equivalence.[53] With quadratic preferences, a constant interest rate equal to the rate of time preference, and non-human wealth evolving as $A_t = (1+r)(A_{t-1}+Y_{t-1}-C_{t-1})$, consumption changes can be written in closed-form:

$$C_t - C_{t-1} = \sum_{s=0}^{H-t} w_s(\mathbb{E}_t - \mathbb{E}_{t-1})(Y_{t+s} - T_{t+s}).$$

Y is income before taxes T, and the annuity weights are given by $w_s = \frac{r}{1+r}[1 - \frac{1}{(1+r)^{H-t+1}}]^{-1}(1+r)^{-s}$. Following Campbell and Deaton (1989), I normalize consumption changes by income, thereby expressing tax liabilities as average tax rates and making the model scale independent, a particularly useful feature when working with micro data.[54] Specifically, I divide by predetermined adjusted gross income Y asked in the first interview, thereby avoiding the endogeneity that would arise if we used current or future income, i.e., income asked in the last interview. To bring the model more closely to the data, I replace the constant annuity weights with the weights based on real after-tax

high-income investors in higher brackets; see Figure 3.

[53] A similar interpretation can be derived by log-linearizing the inter-temporal budget constraint; see Campbell and Deaton (1989).

[54] The robustness section shows similar results when using lagged consumption (appropriately rescaled) as a normalization of consumption changes.

discount factors used in the previous section, and I limit the household's planning horizon H to the maximum available maturity M (usually 30 years),

$$\frac{C_t - C_{t-1}}{Y} \approx -\sum_{s=0}^{M} w_{t,s}^{(M)} (\mathbb{E}_t - \mathbb{E}_{t-1})\bar{\tau}_{t+s} + \varepsilon_t. \tag{8}$$

(8) shows that to a first approximation, changes in expected *average* tax rates determine the growth rate of consumption. Moreover, the tax news shocks has a natural interpretation: It is the change in the expected annuity value of average tax liabilities, which is the permanent component of expected future tax changes. The error term ε contains measurement error in consumption growth as well as economic shocks such as news about future income growth and any other shocks that the model ignores.[55]

In an ideal setting I would observe news shocks for each tax rate in each tax bracket as well as news about changes of those tax brackets. Integrating over expected brackets and rates would then allow me to compute expected average tax rates for each household. In practice I only observe news about the top tax rate. To go from expected top marginal tax rates to expected average tax rates I have to make two assumptions. First, I assume that changes in the tax base–if they do occur–are perfectly foreseen. With the exception of TRA 1986, which is discussed in more detail in the online appendix, this assumption is reasonable for the income tax reforms in my sample because the brackets did not change much. Second, I scale the perfect-foresight tax rate $\tau_{t+s}(b)$ in each lower income bracket $b < B$ (where B denotes the top tax bracket) by the ratio of the market-based expected top tax rate $\mathbb{E}_t\tau_{t+s}(B) = \mathbb{E}_t\tau_{t+s}$ to the perfect-foresight top tax rate $\tau_{t+s}(B) = \tau_{t+s}$, taken from Saez (2004), such that[56]

$$\mathbb{E}_t\tau_{t+s}(b) = \tau_{t+s}(b)\,\frac{\mathbb{E}_t\tau_{t+s}(B)}{\tau_{t+s}(B)}. \tag{9}$$

Thus, if households have perfect foresight about the top marginal tax rate, I assume that they also have perfect foresight about the lower bracket rates. With this assumption, changes in expected averages tax rates (for household i) in equation (8) can be written as

$$(\mathbb{E}_t - \mathbb{E}_{t-1})\bar{\tau}_{i,t+s} = \sum_b B_{i,t+s}(b)\tau_{t+s}(b)\frac{(\mathbb{E}_t - \mathbb{E}_{t-1})\tau_{t+s}}{\tau_{t+s}} = \frac{\bar{\tau}_{i,t+s}}{\tau_{t+s}}\,(\mathbb{E}_t\tau_{t+s} - \mathbb{E}_{t-1}\tau_{t+s}),$$

[55] The model abstracts from three main effects. First, it does not capture the effect of marginal tax rates on consumption via the inter-temporal substitution channel triggered by changes in the effective after-tax interest rate. Empirical evidence suggests that the effect of the interest rate (and hence the marginal tax rate) on the saving rate is small; e.g., Deaton (1992). Second, certainty equivalence ignores the effect of tax uncertainty on household consumption through changes in precautionary savings. Finally, the model ignores any effects of changes in expected marginal tax rates on labor supply and its impact on consumption via either wealth channel or non-separability of consumption and leisure. The regression coefficient derived below can therefore also be interpreted as a reduced form of a more general model that would explicitly model–and more importantly also separately identify–those channels, which is beyond the scope of this paper.

[56] Since the sampling frequency is quarterly at the household-level while expectations are formed over annual intervals, I assume that the perfect-foresight variables do not change between quarters, so that $(\mathbb{E}_{t+1} - \mathbb{E}_t)\tau_{t+s}(b) = \tau_{t+s}(b)\ \frac{(\mathbb{E}_{t+1}-\mathbb{E}_t)\tau_{t+s}}{\tau_{t+s}}$.

where $B_{i,t+s}(b)$ is the income household i receives in tax bracket b. The expected change in the top tax rate $(\mathbb{E}_t - \mathbb{E}_{t-1})\tau_{t+s}$, which is identified using the municipal yield spreads, can now be interpreted as the signal that the household receives between date $t-1$ and t. The term $\frac{\bar{\tau}_{i,t+s}}{\tau_{t+s}}$ is a measure of the relevance of the signal for the household's consumption decision. One can think of this ratio as an importance weight for the signal: If this ratio is low then the impact of news about the top tax rate in s years has only a small impact on the household's expected after-tax lifetime income, and a rational household should therefore largely ignore the signal. On the other hand, if the ratio is large, then the household should pay close attention to the signal.

It is important to note that this assumption does *not* imply that the expected change in the *average* tax rate is the same for all households. To see this, suppose that the expected future tax schedule in s years from now has only two tax rates, 10% and 50%. Let the first tax bracket range from \$0 to \$10,000 so that all income above \$10,000, which is the second income bracket, is expected to be taxed at the 50% rate. Suppose that the expected top tax rate increases by 10%, i.e. $\frac{\Delta_t \mathbb{E}_{t+1}\tau_{t+s}(B)}{\tau_{t+s}(B)} = 0.1$ such that the lower tax rate increases by 1 percentage point from 10% to 11% and the top tax rate by 5 percentage points from 50% to 55%. The expected average tax rate of a household with an income of \$10,000 increases by 1 percentage point, while the expected average tax rate of a household with an income of \$15,000 increase by 2¹/₃ percentage points. Moreover, the expected change of the average tax rate approaches 5 percentage points as income goes to infinity, which equals the expected change of the top tax rate. Figure 4 in the online appendix shows the cross-sectional treatment heterogeneity for each tax reform in the sample. Using the NBER TAXSIM calculator, I compute perfect-foresight average tax rates $\{\bar{\tau}_{i,t+s}\}_{s=0}^{M}$ for each household i in the CEX that depend on the head of household's age and the household's predetermined income percentile. These income profiles allow for predictable changes in average tax rates due to the hump shape of the life-cycle income profile and are described in more detail in the online appendix.

The assumption in equation (9) is least restrictive for high-income households for which changes in the top tax rate are closely related to changes in their average tax rate. For this reason I focus on the consumption response of high-income households to tax news. In the online appendix I show that changes in average tax rates for households in the top quartile of the income distributions are highly correlated over the sample period, although they are not perfectly correlated. I therefore choose the top income quartile of households (by tax filer status) in the CEX as my baseline sample, and I then analyze how the results change as I change this threshold. The different cut-offs trade off measurement error with statistical power: While including more households that are further away from the top tax bracket increases the precision of the estimates, it potentially biases the results if assumption (9) is less appropriate for those additional households, i.e., if tax news shocks are less well measured with municipal yield spreads for those households.

The model provides both a prescription for how to construct the tax news shocks for each household in the CEX as well as an interpretation of the coefficient β of the following regression of the consumption growth rate on the tax news shock,

$$\frac{C_{it} - C_{i,t-1}}{Y_i} = \beta \underbrace{\left(\sum_{s=0}^{M} w_{t,s}^{(M)} \; \frac{\bar{\tau}_{i,t+s}}{\tau_s} \; \left(\mathbb{E}_t \tau_{t+s} - \mathbb{E}_{t-1} \tau_{t+s} \right) \right)}_{\text{tax news shock}} + \alpha_t + \phi' z_{it} + \varepsilon_{it}. \tag{10}$$

The permanent income hypothesis predicts that $\beta = -1$, i.e., that consumption moves one-for-one with a permanent shock to after-tax income. However, one should keep in mind the many simplifying assumptions discussed above that were required to obtain such a sharp prediction. The main purpose of the model is therefore to provide an interpretation of the magnitudes that one would expect to obtain when running such regressions under the null hypothesis that the basic rational-expectations permanent income theory is correct.

α_t is a full set of time fixed effects and z_{it} is a vector of additional controls that are standard in the literature. In particular, z_{it} includes a quadratic in the age of the reference person, quarterly changes in the number of adults and children, as well as other household characteristics such as family size, the maximum level of education achieved by either the reference person or the spouse, marital status, and the composition and number of earners. Furthermore, it also contains all the variables used to construct the tax news shock–which is an interaction term–, such as federal adjusted gross income (AGI) in levels and as percentile fixed effects, the household's tax filing status, all perfect-foresight average tax rates, and the tax news shock formed with the residual of the low-pass filter applied to the break-even tax rates; see section 1.

2.1 Identification

The tax news response β is identified if news about future tax changes are uncorrelated with other news, in particular with other news about before-tax household income, conditional on z_t and monthly fixed effects α_t, that is if $\mathbb{C}\text{ov}(\sum_{s=1}^{M} w_{t,s}^{(M)} \frac{\bar{\tau}_{i,t+s}}{\tau_{t+s}} (\mathbb{E}_t \tau_{t+s} - \mathbb{E}_{t-1} \tau_{t+s}), \varepsilon_{it} | z_{it}, \alpha_t) = 0$. Monthly fixed effects control for changes in the average interest rate, and they also control for the extent to which fiscal policy is used to counteract aggregate fluctuations in economic activity. While fiscal policy was extensively used prior to the 1980s, it was largely replaced by monetary policy as the main countercyclical policy tool since then, at least until very recently. For instance, Romer and Romer (2010) find that all income tax changes between 1980 and 2003–with one minor exception in 2001–are not countercyclical nor did they coincide with changes in government spending.[57] Romer and Romer therefore classify those income tax reforms as exogenous, driven either by attempts to increase long-run economic growth (ERTA 1981, TRA 1986, EGTRRA 2001 and JGTRRA 2003) or by concerns about the federal budget deficit (OBRA 1990 and OBRA 1993).

[57] The minor exception is the Economic Growth and Tax Relief Reconciliation Tax Act of 2001 (EGTRRA). The countercyclical part of EGTRRA concerns the accelerated implementation of the tax cuts but it does not concern the overall size of the cuts. For instance, Romer and Romer (2008) note that "this [countercyclical] motivation was almost always discussed in the context of making some of the cuts retroactive to January 1, 2001 rather than having them begin on January 1, 2002." (p.84)

While the tax reforms in the sample are orthogonal to the current state of the economy–and hence exogenous according to the terminology of Romer and Romer (2010)–, the corresponding tax news shocks might nevertheless be correlated with news about future income. Thus, while it is not possible to fully rule out that the consumption response is at least partially driven by correlated income news shocks, a consumption response to either type of shock still indicates that households are forward-looking.

One final concern is that liquidity shocks to the bond markets are correlated with the business cycle or with bad income news in general. When financial markets are under stress–such as during the financial crisis of 2008-2010–the liquidity premium on Treasury bonds tends to increase. Such periods are also associated with lower consumption. An increase in the demand for liquidity provided by Treasury bonds relative to municipal bonds increases the relative price for Treasuries and hence lowers the Treasury yield relative to the yield on municipal bonds. Equation (3) shows that this mechanism causes the BETRs θ_t to decrease and therefore decreases the measured path of expected forward tax rates $\mathbb{E}_t\tau_t$. To the extent that such liquidity shocks are not absorbed by monthly fixed effects or by the filtering of the time series, they induce a spurious *positive* correlation between changes in the measured path of expected tax rates and consumption changes. This possible correlation leads the response coefficients to be biased against the rational-expectations model. For these reasons–that income tax reforms in the sample are exogenous to the current state of the economy, and that any remaining liquidity shock biases the results against the basic rational-expectations model–running regressions of the form of (10) should provide a meaningful assessment of the response of high-income households' consumption to news about future taxes.

To summarize, I combine two sources of variation to identify the response of household consumption to news about future income taxes. First, I use changes in the path of expected top tax rate to identify the quantity of new information revealed at each point in time. Second, I use cross-sectional variation in expected *average* tax rates since changes in expected average tax rates determine the response of household consumption in the basic rational-expectations life-cycle model.

2.2 Results

The online appendix documents the consumption data and provides summary statistics of the main variables. Due to extreme outliers I windsorize consumption growth at the 10% level, and I check the robustness of the results to this choice in the next section. Table 3 shows the main results of the analysis. Column 1 regresses growth of nondurable consumption including services for the sample of households with a federal AGI above the 75th percentile (by tax filer status) on the tax news shock, controlling only for aggregate shocks using time fixed effects. The response of consumption to tax news is roughly one-for-one (in absolute value) as predicted by the permanent income hypothesis. Column 2 runs the same regression on the sample of households with an AGI above the 90th percentile, for whom the news shock should be measured with less error. While the precision decreases by about 50% as expected based on the substantial reduction in sample size, the point estimate is almost unchanged and remains statistically significant. Column 3 is the preferred specification using the sample of households with AGI above the 75th percentile and adding the full set of control variables. The point estimate is again close to -1 and highly significant. This of course does not confirm the basic model, and given the relatively large standard errors many other models that also feature forward-looking behavior are consistent with the estimated response.

The control variables have the expected impact on consumption growth. The negative coefficient for age and the positive coefficient for age squared are consistent with a hump-shaped life-cycle consumption profile. Adding a family member increases consumption growth, more so for an additional adult than an additional child. Importantly, the effect of the news shock using the low-pass residuals is economically small and is not statistically significant, suggesting that this procedure indeed filters out the variation of the bond-based tax news shock that does not affect household consumption decisions, such as bond market liquidity shocks and measurement error. In the next section I will explore this point in more detail.

Columns 4 to 6 analyze how the estimated effect of a tax news shock changes as we chose different samples based on federal AGI. When we include all household above the AGI median, the coefficient drops to -0.5, while the response of households below the median is only -0.1 and no longer statistically significant. The two main competing explanations for this pattern are measurement error in the tax news shock and economic or behavioral frictions. By extending the sample to households that face tax rates much lower than the top rate, the mapping from news about the top tax rate to changes in expected average tax rates that those households face becomes less plausible. On the other hand, lower income household might also be exposed to more consumption adjustment frictions such as liquidity constraints and might also be more subject to behavioral frictions such as myopia or near rationality than high-income households. While a detailed analysis of this pattern is beyond the scope of this paper, a promising avenue for future research is to identify news shock that affect lower income households more directly.

Finally, column 7 runs the same specification as in column 1 except for the time fixed effects. As one would expect, not controlling for aggregate shocks and countercyclical policy responses to such shocks biases the coefficient upward, resulting in a value close to zero that is economically and statistically insignificant.

2.3 Robustness

Table 4 reports tests of the robustness of the finding that news about future tax changes strongly affect current consumption of high-income households. In particular, I investigate the sensitivity of the results to outliers in consumption, to different procedures of filtering the tax news shocks, to the sample period, and to the normalization of the consumption changes. In all the specifications I use the baseline sample of households with an AGI above the 75th percentile and the full set of controls as in column 3 of Table 3.

Column 1 of Table 4 shows the effect of windsoring consumption growth rates at the 5% instead of the 10% level. The larger variability of consumption increases both the estimated response to tax news and the standard error by about 30% in absolute value. Given the large standard errors, we cannot reject that the response to tax news is the same as in column 3 of Table 3.

A related issue is potential mis-measurement of the tax news shock. The results so far have used the two-sided low-pass filter as described in section 1. One might be worried by the fact that a two-sided filter uses not only current and lagged observations, but also future ones. Therefore, the econometrician might overestimate the information set of consumers, thereby underestimating the response to news. This would be the case if households tried to infer the path of expected tax rates $\mathbb{E}_t\tau$ from municipal yield spreads θ_t. The households and the econometrician would solve effectively the same signal extraction problem in real time. Therefore, in this scenario the econometrician should only use current and past bond prices to infer the households' information sets. The difference between the two ways of modeling information can be seen from the way the econometrician solves the signal extraction problem of equation (4). The approach taken so far implies that the optimal solution is a two-sided filter, while this alternative view requires the use of a backward-looking one-sided filter. To account for this possibility, I use the optimal one-sided Hodrick-Prescott filter suggested by Mehra (2004), and I follow Ravn and Uhlig (2002) in setting the smoothing parameter. One-sided filters only use current and lagged observations, but induce a phase-shift; that is, the filtered series lags the raw data and hence detects a change in the trend only with some delay. This phase-shift, shown in Figure 5 of the online appendix, introduces measurement error in the news shock and might therefore bias the consumption response toward zero if households do not use municipal bonds to infer future tax rates.

Column 2 shows the consumption response of high-income households to tax news shocks using the one-sided filter. While the results are robust to applying a one-sided filter, the phase-shift of the series caused by the one-sided filter lowers the consumption response in absolute value relative to the response using the two-sided filter, shown in column 3 of Table 3. Hence, this suggests that households do not use municipal yield spreads to infer future tax rate, but instead that news about future tax rates simultaneously affects both relative bond prices as well as household consumption decisions. To see this point more clearly, column 3 of Table 4 uses the series without any filtering. As expected, the noise introduced by liquidity shocks biases the consumption response to zero. In fact, the attenuation bias is almost complete, resulting in an estimated response that is economically and statistically insignificant.

Next, I analyze the response in different sample periods. As discussed in section 1 and seen in Figure 2, in the absence of additional variation from election probabilities, the bond-based measure of expected tax rates works well in the late 1990s and particularly in the early 1980s when marginal rates changed dramatically. However, the break-even tax rates at short maturities behave poorly in the early 1990s. Columns 4 to 7 split the sample accordingly in order to investigate whether the consumption response also reflects this pattern. Indeed, column 4 shows that the response is strongest during Ronald Regan's presidency, while it has the same magnitude as in the full sample during the Bill Clinton's presidency (column 6) and is slightly lower at the beginning of George

W. Bush's presidency (column 7).[58] Moreover, the consumption response during George H. Bush's presidency from 1989 to 1992, which coincides with the break-down of the bond-based identification of tax news shocks at shorter maturities, is slightly positive and not statistically significant. The positive consumption response to the estimated expected tax increases in this period is consistent with the fact that short-term break-even tax rates move in opposite direction to the top marginal tax rate.

Finally, column 8 uses lagged consumption as an alternative normalization of consumption changes, which is the specification obtained when log-linearizing the inter-temporal budget constraint; see Campbell and Deaton (1989).[59] The point estimate is very similar to the baseline specification in column 3 of Table 3, while the standard error is slightly smaller.

Overall, the results in Table 4 show that the estimated response to tax news is similar under alternative specifications. More importantly, the point estimates change in the direction we would expect if the tax news shocks indeed measure the persistent component of changes in expected future tax liabilities: The response is lower in absolute value than predicted by the permanent income hypothesis if we use noisier shocks (columns 2, 3, and 5), and it is in line with the theory if we filter out the noise or when looking at periods during which we would expect the identification approach to work best (columns 1, 4, and 6-8).

3 Conclusion

This paper identifies tax expectations using the yield spread between taxable and tax-exempt bonds with maturities of one to thirty years. Combining these tax expectations with household consumption data shows that the basic rational-expectations life-cycle model describes the behavior of high-income households remarkably well. This paper is the first to directly measure the response of household consumption to news shocks, and thus is the first direct test of the theory's prediction for the response of household consumption to new information.

While a full analysis of the macroeconomic implications of these results is beyond the scope of this paper, it is nevertheless useful to discuss two issues related to fiscal policy. First, the response of household consumption to news about future tax policies suggests that studies which ignore anticipation effects do not capture the total effect of a tax change on the economy. Whether the anticipation effect documented in this paper amplifies or dampens the effect that such studies typically find–for example due to households that exhibit excess sensitivity in consumption–depends on how this policy changes households' expectations about other future tax policies. For example, a tax reform that is expected to permanently lower taxes would cause unconstrained forward-looking households to respond to the news, while constrained households (either because of economic or behavioral frictions) would respond to the actual tax change, in which case the total measured effect

[58] In order to have a reasonable sample size the time periods in columns 6 and 7 do not exactly coincide with Clinton or Bush's time in office.

[59] To make the coefficient comparable with the previous specifications, I scale the series by the sample median of the ratio of consumption to predetermined income.

of a tax reform would be amplified by including the anticipation effects. On the other hand, a tax stimulus that targets constrained households and is expected to be paid for by increasing taxes on unconstrained households in the future would cause the anticipation and excess sensitivity effects to go in opposite directions, thereby dampening the total effect of the stimulus.

Second, while the anticipation effect could partially overcome the long implementation lag of fiscal policies–which is a major limitation of taxes as a short-run policy instrument–, the fact that countercyclical policies are usually designed to be budget neutral over the business cycle implies that forward-looking households might realize that a countercyclical tax policy has little effect on their lifetime income and might thus respond neither to the news nor to the actual tax change.

Clearly, more research on the response of households to news shocks needs to be undertaken before such data can offer policy guidance that is empirically well-grounded. Identifying more news shocks that directly affect household budget sets is clearly desirable in order to verify the results of this study. A particularly useful task is the identification of news shocks that affect lower-income households directly. Such additional independent news shocks could be used to more thoroughly examine the cause of the different responses between high-income and lower-income households reported in this paper.

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Table 1: Personal state income taxes on interest income.

Type of Bond :	In-State Municipal	Out-of-State Municipal	Treasury	Corporate		
Alabama	exempt	taxable	exempt	taxable	3.65	1988-90
Alaska		*no personal income tax 1979-2010*			14.5	1977-78
Arkansas	exempt	taxable	exempt	taxable	7.43	2003-04
Arizona	exempt	taxable	exempt	taxable	6.74	1992-93
California	exempt	taxable	exempt	taxable	11.66	1991-95
Colorado	exempt	taxable	exempt	taxable	5.15	1992-98
Connecticut*	exempt	taxable	exempt	taxable	5	2003-10
Delaware	exempt	taxable	exempt	taxable	19.8	1977-78
Florida		*no personal income tax 1977-2010*				
Georgia	exempt	taxable	exempt	taxable	6	1977-86
Hawaii	exempt	taxable	exempt	taxable	10.01	2009
Idaho	exempt	taxable	exempt	taxable	8.28	1991-99
Illinois	*taxable*	taxable	exempt	taxable	3	1990-2010
Indiana	exempt	*exempt*	exempt	taxable	3.4	1988-2010
Iowa	*taxable*	taxable	exempt	taxable	7.39	1988-90
Kansas	exempt	taxable	exempt	taxable	6.91	1983-84
Kentucky	exempt	taxable	exempt	taxable	6.18	1991-2005
Louisiana	exempt	taxable	exempt	taxable	4.14	1988-90
Maine	exempt	taxable	exempt	taxable	10.19	1991-92
Maryland	exempt	taxable	exempt	taxable	7.5	1977-78
Massachusetts*	exempt	taxable	exempt	taxable	6.25	1991
Michigan	exempt	taxable	exempt	taxable	6.35	1983
Minnesota*	exempt	taxable	exempt	taxable	9.65	1983
Mississippi	exempt	taxable	exempt	taxable	5.07	1992-2005
Missouri	exempt	taxable	exempt	taxable	6.07	1994-2005
Montana*	exempt	taxable	exempt	taxable	9.02	1988
Nebraska	exempt	taxable	exempt	taxable	11.19	1977, 1979
Nevada		*no personal income tax 1977-2010*				
New Hampshire		*no personal income tax 1977-2010*				
New Jersey*	exempt	taxable	exempt	taxable	10.75	2009
New Mexico	exempt	taxable	exempt	taxable	8.26	1977-80
New York*	exempt	taxable	exempt	taxable	15	1977-78
North Carolina	exempt	taxable	exempt	taxable	8.5	2001-05

Table 1 (continued)

Type of Bond :	**In-State Municipal**	**Out-of-State Municipal**	**Treasury**	**Corporate**		
North Dakota	exempt	taxable	exempt	taxable	5.41	1993-2005
Ohio	exempt	*exempt*	exempt	taxable	9.03	1984
Oklahoma	exempt	taxable	exempt	taxable	6.65	1991-92
Oregon*	exempt	taxable	exempt	taxable	13	1977-78
Pennsylvania*	exempt	*exempt*	exempt	taxable	3.07	2004-10
Rhode Island	exempt	taxable	exempt	taxable	11.79	1983
South Carolina	exempt	taxable	exempt	taxable	7.08	1991-2005
South Dakota		*no personal income tax 1977-2010*				
Tennessee		*no personal income tax 1977-2010*				
Texas		*no personal income tax 1977-2010*				
Utah	*taxable*	taxable	exempt	taxable	7.75	1987
Vermont	exempt	taxable	exempt	taxable	14.88	1977-78
Virginia	exempt	taxable	exempt	taxable	5.82	1991-2005
Washington		*no personal income tax 1977-2010*				
Washington D.C.	exempt	taxable	exempt	taxable	11	1982-86
West Virginia*	exempt	taxable	exempt	taxable	12.7	1984
Wisconsin*	*taxable*	taxable	exempt	taxable	11	1983
Wyoming		*no personal income tax 1977-2010*				

Source: Temel (2001), updated by the author. Maximum state income tax rates 1977-2010 are provided by Daniel Feenberg, http://www.nber.org/~taxsim/state-rates/.
* The following states tax corporations on all interest income: Connecticut, Massachusetts, Minnesota, Montana, New Jersey, New York, and Oregon. Pennsylvania exempts corporations from all taxes on interest. West Virginia and Wisconsin tax corporations on their interest income from municipal bonds, but exempt interest from Treasury bonds.

Table 2: Break-even tax rate responses to changes in election probabilities.

	Maturity (m)							
Break-Even Tax Rate $\theta_{t,m}$ (BETR) :	1-Year	2-Year	3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
Price of Bush Contract in 2000 [in cents]	0.018	-0.018***	-0.031***	-0.033***	-0.028***	-0.024**	-0.006	0.003
	(0.013)	(0.007)	(0.007)	(0.007)	(0.010)	(0.011)	(0.009)	(0.013)
Price of Clinton Contract in 1992 [in cents]	0.140***	0.096**	0.140***	0.091***	0.097***	0.103***	0.042***	0.047**
	(0.048)	(0.047)	(0.040)	(0.026)	(0.022)	(0.021)	(0.015)	(0.018)

Notes: This table shows the results from regressing daily election probabilities on break-even tax rates for the presidential election of 2000 and 1992, respectively. The tax reform enacted in 1993 (OBRA 1993) increased the statutory top income rate by 8.6% from 31% to 39.6% retroactively to January 1, 1993. The tax reform enacted in 2001 (EGTRRA 2001) reduced the statutory top income rate by 4.6% from 39.6% to 35% over 5 years and the reform in 2003 (JGTRRA 2003) accelerated the phase-in period to three years. The contracts yield 100 cents if the candidate wins and zero otherwise. Therefore, an increase of the price by 1 cent corresponds to a 1% increase in the perceived probability of the candidate winning the presidential election. The full regression results are provided in the online appendix. Newey-West HAC robust standard errors in parentheses: ***, **, * mark significance at the 1, 5, and 10 percent level, respectively.

Table 3: Response of consumption to tax news.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dep.: nondurables growth	AGI > p(75)	AGI > p(90)	AGI > p(75)	AGI > p(90)	AGI > p(50)	AGI ≤ p(50)	AGI > p(75)
tax news shock [in %]	-1.069***	-0.985**	-0.980***	-0.976*	-0.522**	-0.101	0.032
	(0.306)	(0.470)	(0.318)	(0.504)	(0.213)	(0.232)	(0.057)
age of reference person			-0.111**	-0.138	-0.069**	-0.028	
			(0.049)	(0.094)	(0.028)	(0.038)	
$(\text{age})^2/100$			0.113**	0.123	0.067**	0.041	
			(0.052)	(0.100)	(0.030)	(0.042)	
Δ adults			1.400***	1.394***	1.377***	1.656***	
			(0.169)	(0.234)	(0.133)	(0.216)	
Δ kids			0.426**	0.509	0.523***	0.605***	
			(0.204)	(0.324)	(0.159)	(0.230)	
BP residual of news shock			-0.007	-0.124	0.094	-0.004	
			(0.105)	(0.193)	(0.070)	(0.071)	
Observations	28,101	11,384	28,101	11,384	55,105	52,031	28,101
R^2	0.023	0.031	0.030	0.042	0.022	0.016	0.000
Monthly FE	YES	YES	YES	YES	YES	YES	NO
Household characteristics	NO	NO	YES	YES	YES	YES	NO
Average tax rates $\{\bar{\tau}_{it+s}\}_{s=0}^{M}$	NO	NO	YES	YES	YES	YES	NO
Federal AGI [level + percentiles]	NO	NO	YES	YES	YES	YES	NO
Number of clusters	11793	4811	11793	4811	23076	22394	11793

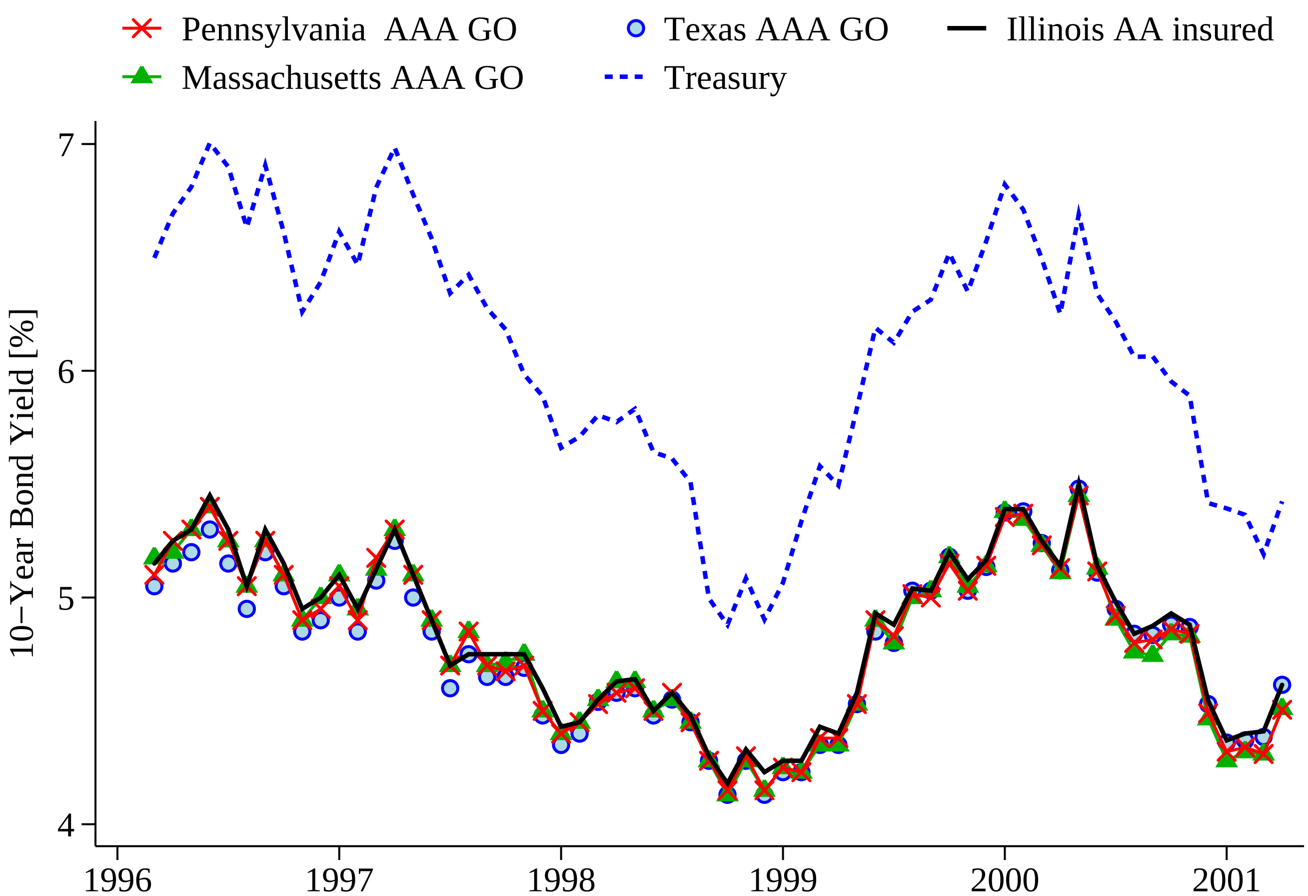
Notes: The dependent variable is household consumption of nondurables and services, described in more detail in the online appendix. AGI is federal adjusted gross income. "BP residual of news shock" is the news shocks constructed from the residual of the band-pass filtered break-even tax rate series. Reported standard errors in parentheses are adjusted for within-household correlation and heteroskedasticity. ***, **, * mark significance at the 1, 5, and 10 percent level, respectively.

Table 4: Consumption response: robustness.

Dep.: nondurables growth	(1) winsorized at 5%	(2) one-sided filter	(3) no filter	(4) sub-sample 1980–1988	(5) sub-sample 1989–1992	(6) sub-sample 1993–1997	(7) sub-sample 1998–2001	(8) nondurables as basis
tax news shock [in %]	-1.316***			-1.274*	0.227	-0.990	-0.749	-0.923***
	(0.401)			(0.671)	(1.347)	(0.960)	(0.466)	(0.353)
tax news shock (one-sided filter)		-0.789**						
		(0.309)						
tax news shock (no filter)			-0.049					
			(0.101)					
age of reference person	-0.131**	-0.115**	-0.121**	-0.105	-0.067	-0.129	-0.080	-0.111**
	(0.058)	(0.049)	(0.049)	(0.113)	(0.123)	(0.092)	(0.087)	(0.053)
$(\text{age})^2/100$	0.133**	0.116**	0.122**	0.074	0.078	0.126	0.109	0.112**
	(0.062)	(0.052)	(0.052)	(0.124)	(0.134)	(0.096)	(0.091)	(0.057)
Δ adults	1.645***	1.399***	1.401***	1.556***	1.919***	0.880***	1.164***	1.670***
	(0.210)	(0.169)	(0.169)	(0.307)	(0.384)	(0.308)	(0.328)	(0.177)
Δ kids	0.519**	0.425**	0.429**	1.006***	-0.554	0.339	0.062	0.340
	(0.243)	(0.204)	(0.204)	(0.376)	(0.465)	(0.316)	(0.452)	(0.218)
BP residual of news shock	0.034			-0.046	0.373*	-0.242	0.021	-0.038
	(0.132)			(0.157)	(0.220)	(0.193)	(0.290)	(0.109)
BP residual of news shock (one-sided)		0.002						
		(0.105)						
Observations	28,101	28,101	28,101	11,174	5,545	6,530	4,852	28,101
R^2	0.029	0.030	0.030	0.036	0.036	0.034	0.027	0.031
Monthly FE	YES	YES	YES	YES	YES	YES	YES	YES
Household characteristics	YES	YES	YES	YES	YES	YES	YES	YES
Average tax rates $\{\bar{\tau}_{it+s}\}_{s=0}^{M}$	YES	YES	YES	YES	YES	YES	YES	YES
Federal AGI [level + percentiles]	YES	YES	YES	YES	YES	YES	YES	YES
Number of clusters	11793	11793	11793	5023	2348	2859	2175	11793

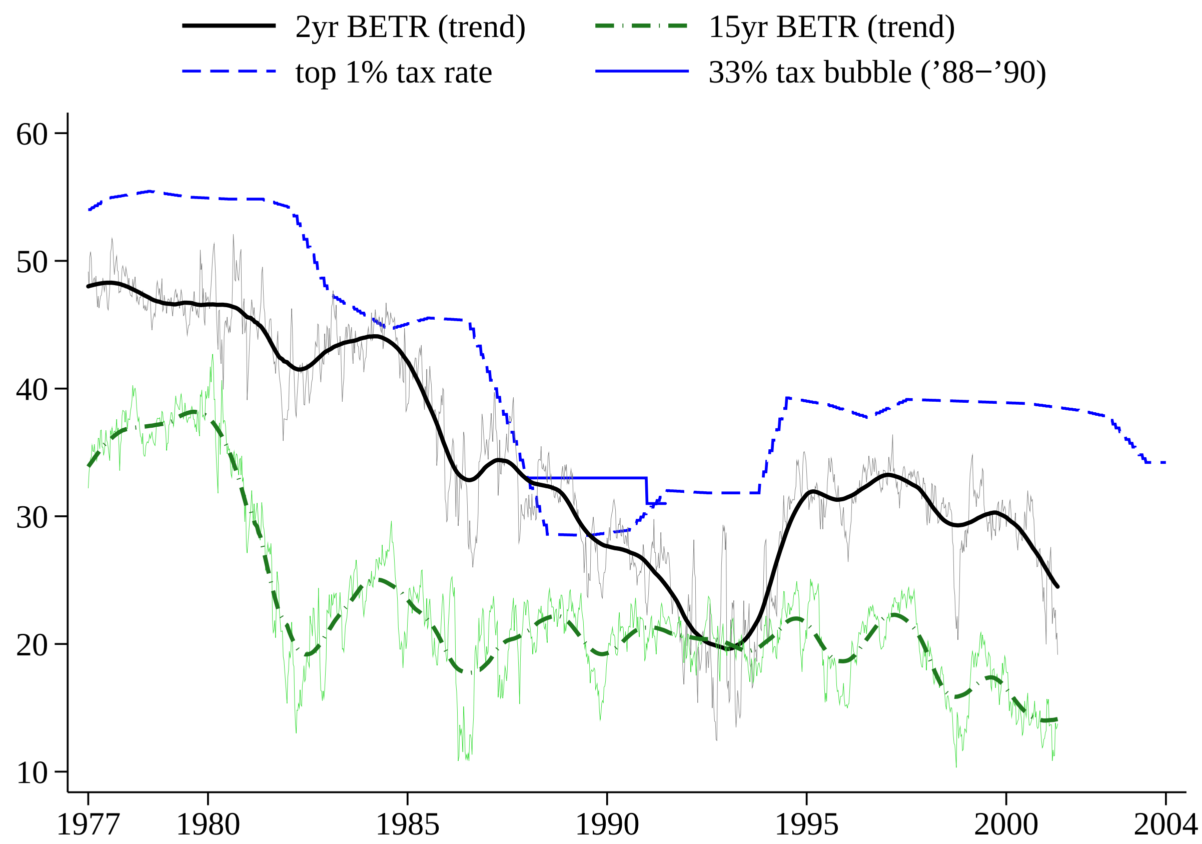
Notes: The dependent variable is household consumption of nondurables and services, described in more detail in the online appendix. AGI is federal adjusted gross income. "BP residual of news shock" is the news shocks constructed from the residual of the band-pass filtered break-even tax rate series. Reported standard errors in parentheses are adjusted for within-household correlation and heteroskedasticity. ***, **, * mark significance at the 1, 5, and 10 percent level, respectively.

Figure 1: Yields of AAA general-obligation (GO) bonds of states with different tax treatment of in- and out-of-state investors.



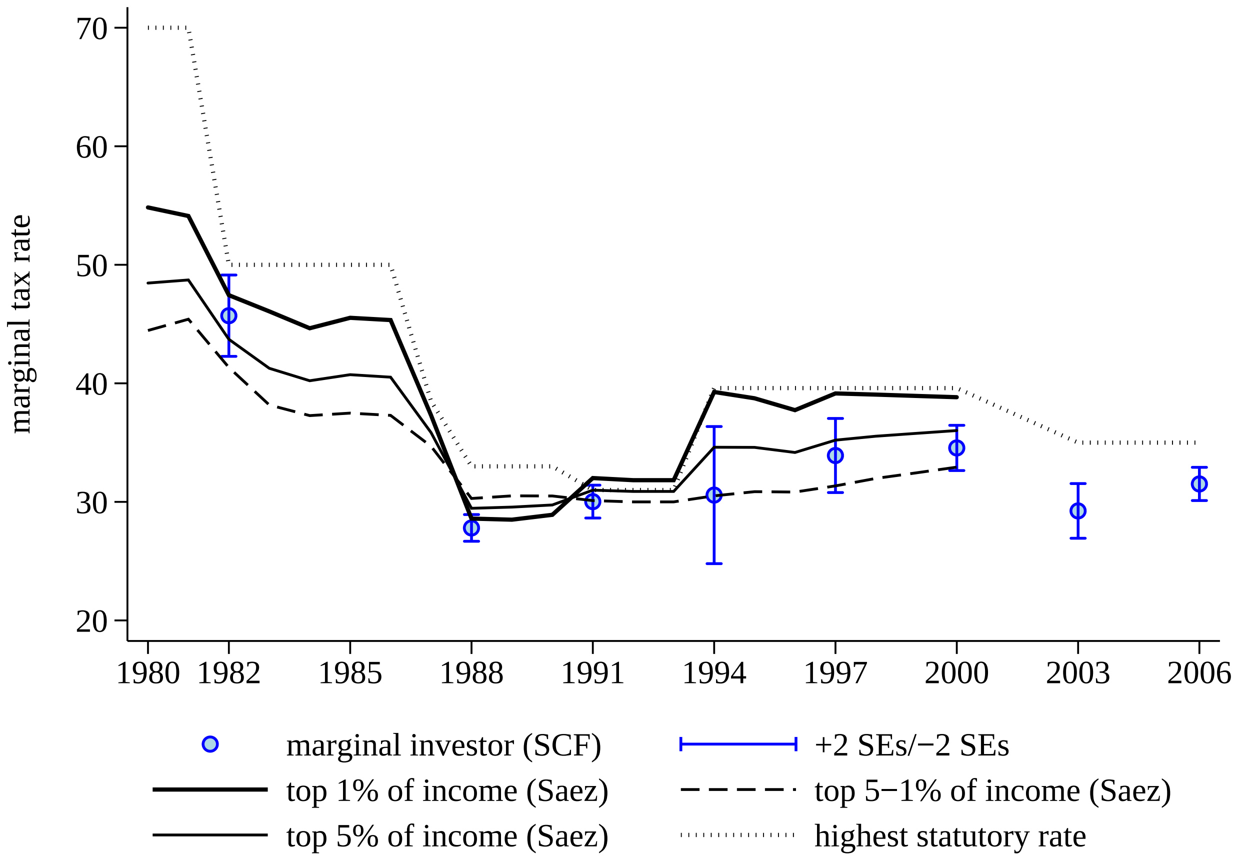
Notes: The blue dashed line is the 10-year Treasury yield, which is taxable at the federal personal income tax rate but is exempt from state and local income taxes; see Table 1. The other four time series are 10-year bond yields of states that span the spectrum of possible tax treatments of in-state and out-of-state municipal bond investors. The red crossed line is the yield of a AAA general-obligation (GO) bond of the state of Pennsylvania, which exempts both in-state and out-of-state municipal bond investors. The green line with triangle markers is the yield of a AAA GO bond of the state of Massachusetts, which exempts in-state investors from state taxes but taxes out-of-state investors. The black solid line is the yield of a AA insured bond of the state of Illinois, which taxes both in-state and out-of-state investors. I use a AA insured bond because there is no AAA GO for the state of Illinois, which is one of only four states that taxes both in- and out-of-state investors–the others being Iowa, Utah, and Wisconsin, for which I do not have bond yield data. Finally, the blue dots represents the time series of AAA GO 10-year bond yields of the state of Texas, which has no personal income tax rate.

Figure 2: 2-year and 15-year break-even tax rates (BETR) $\theta_{t,2}$ and $\theta_{t,15}$ against the marginal tax rate of the top 1%.



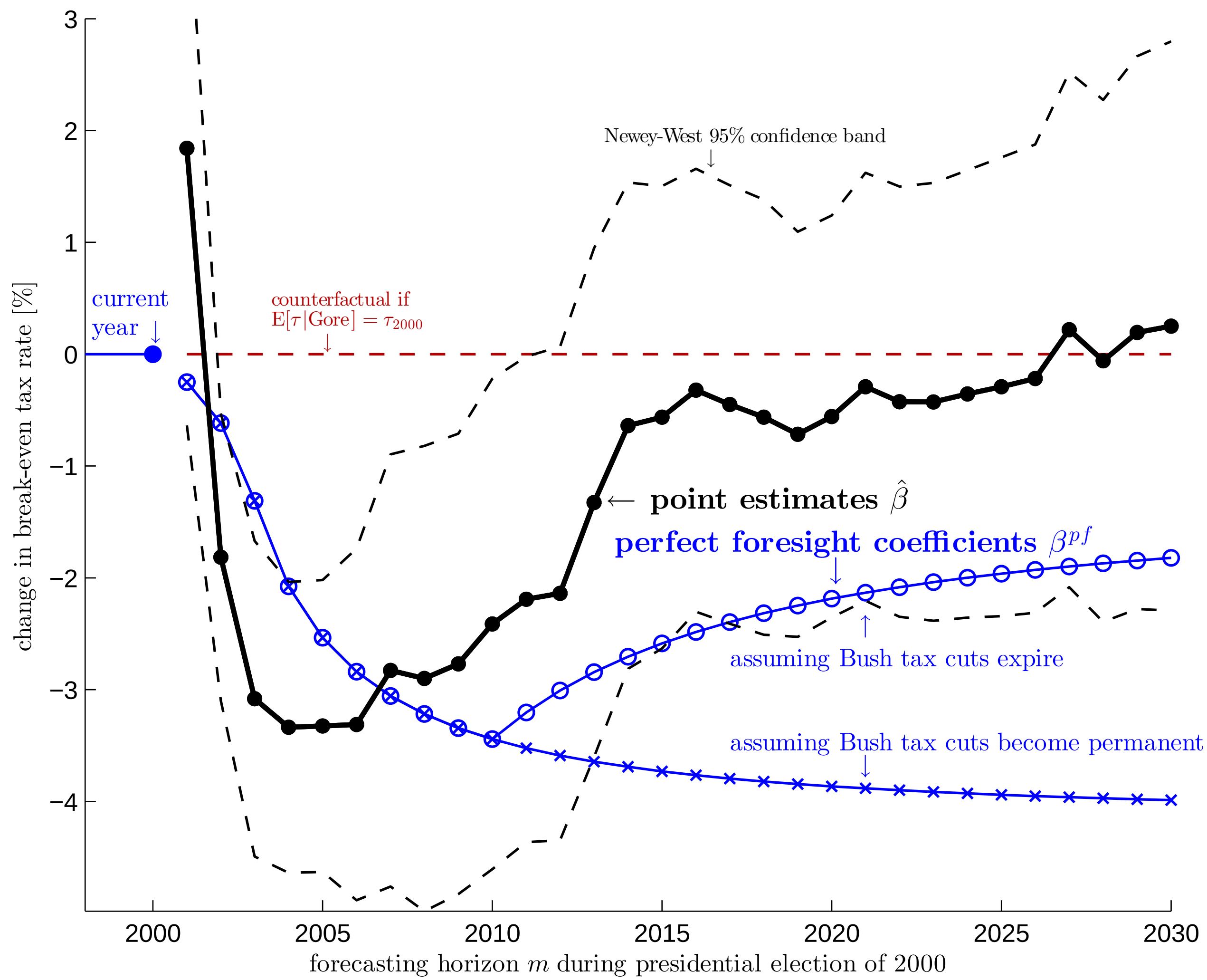
Notes: The thin lines are the raw data and the thick lines are the corresponding low frequency components of the 2-year and the 15-year break-even tax rates, respectively, corresponding to equation (3). The blue thin dashed line is the top 1% tax rate taken from Saez (2004). The solid blue line is the '33% tax bubble' during the years 1988-1990; in this period, the top marginal tax rate is higher than the marginal tax rate of the top 1% of the income distribution.

Figure 3: Average Marginal Tax Rate of the Marginal Investors calculated from the SCF.



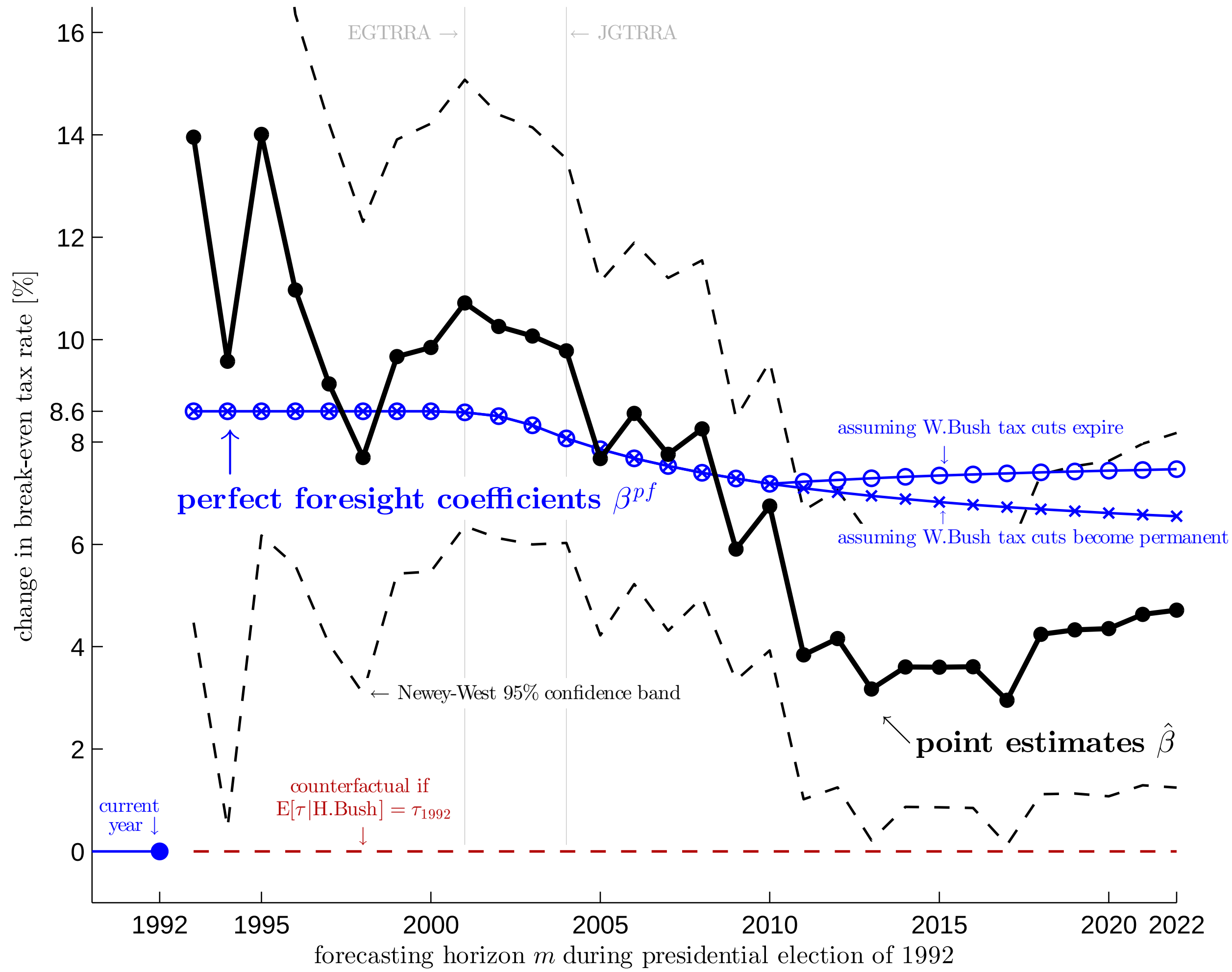
Notes: The blue dots are the estimated marginal tax rate of the marginal investor defined as the asset-weighted average of the effective marginal tax rates over all households that own both taxable and tax-exempt bonds. Two standard error bands are shown around the point estimates of the marginal investor's marginal tax rate. The black lines are the marginal tax rates of different percentiles of the income distribution taken from Saez (2004).

Figure 4: Path of Break-Even Tax Rates during presidential election of 2000.



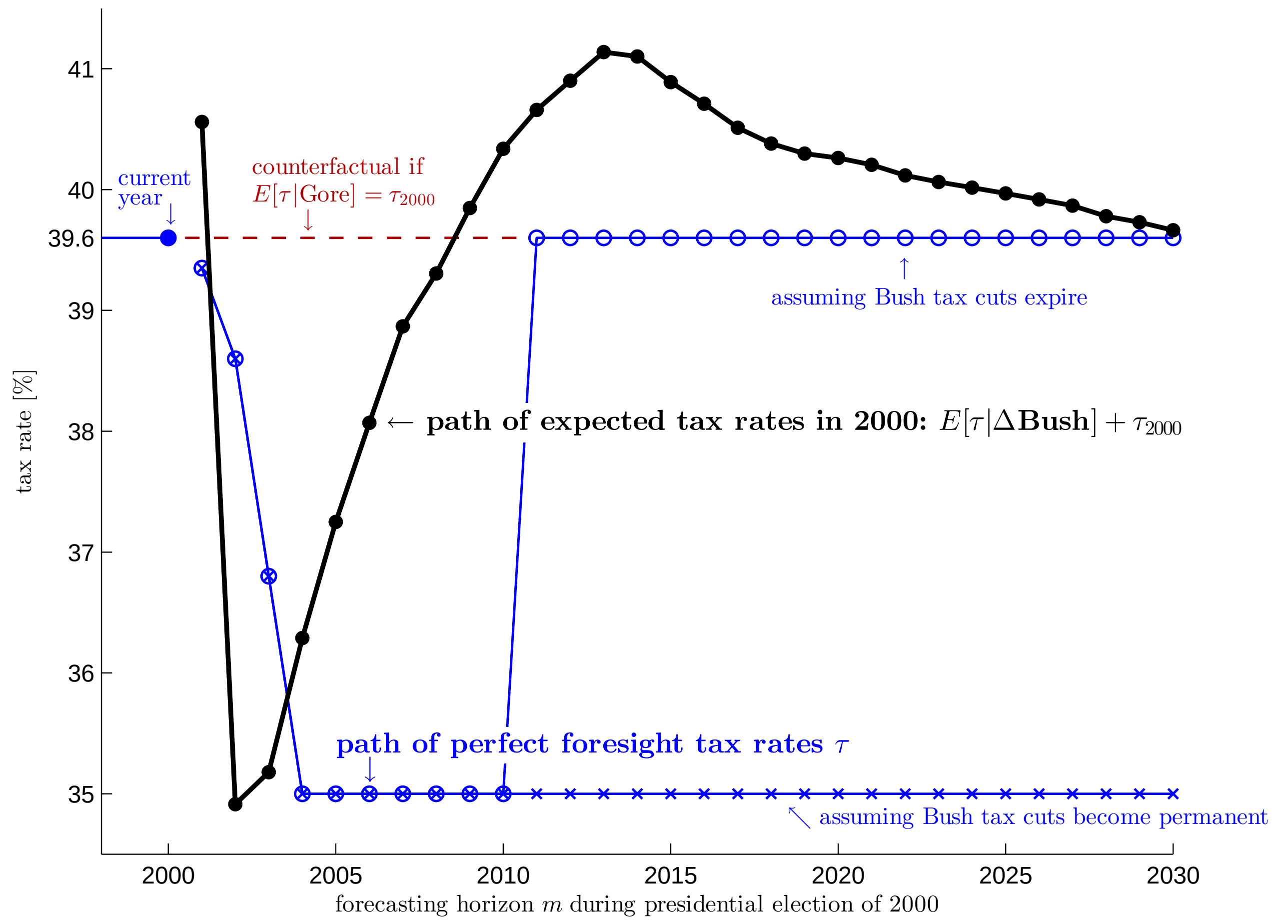
Notes: The black line is the estimated response of the break-even tax rates $\hat{\beta}$ from regression equation (5) to changes in the election probability of George W. Bush during the five months prior to Election Day in 2000; the black dashed lines are 95% Newey-West confidence bands. The blue lines show the population coefficients β^{pf} one should obtain under perfect foresight and assuming that the counter-factual path of tax rates under President Gore is fixed at $\tau_{2000} = 39.6\%$. Two scenarios for the path of future tax rates beyond 2011 are shown, one where the Bush tax cuts expire in 2011 as scheduled and one where they become permanent.

Figure 5: Path of Break-Even Tax Rates during presidential election of 1992.



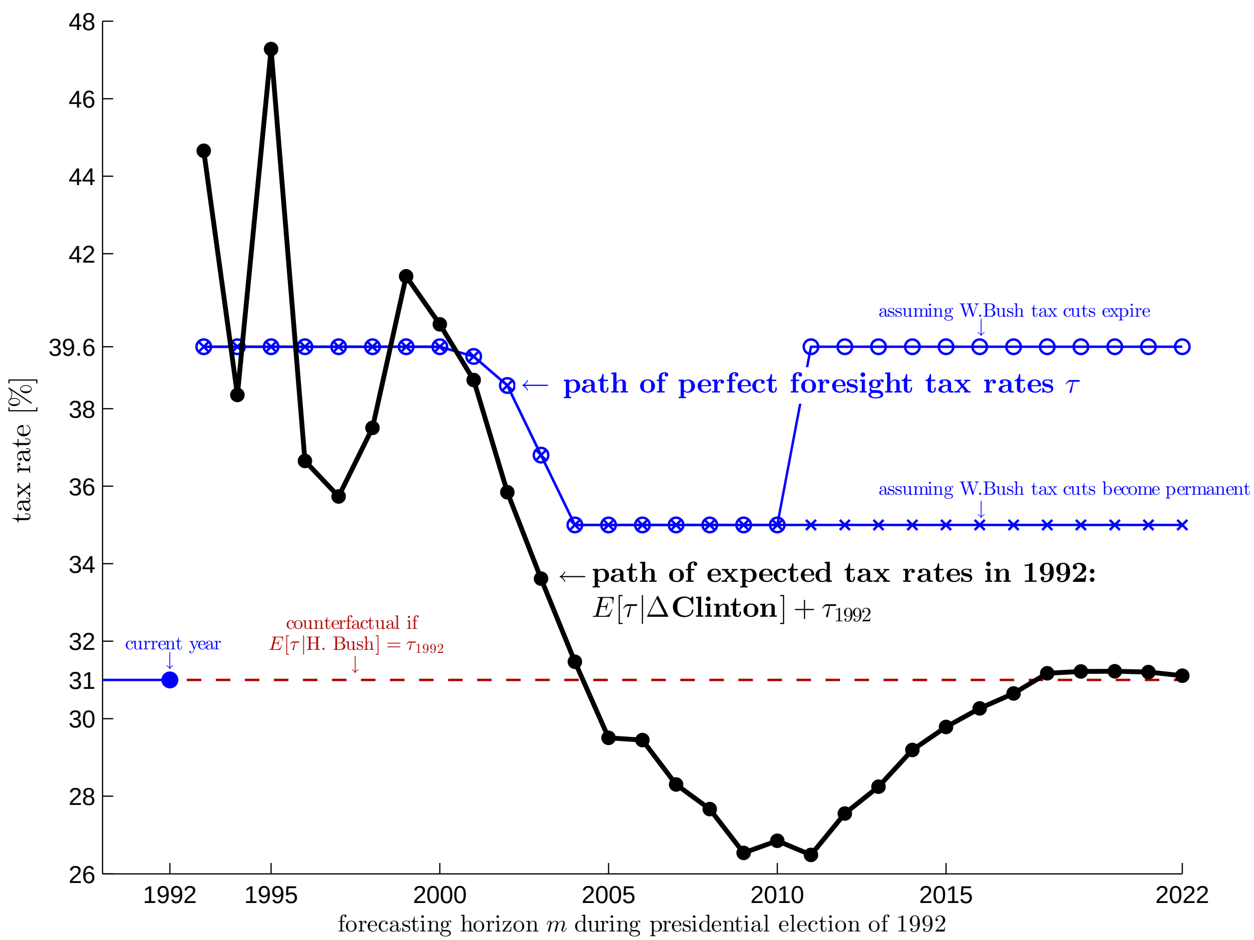
Notes: The black line is the estimated response of the break-even tax rates $\hat{\beta}$ from regression equation (5) to changes in the election probability of Bill Clinton during the three months prior to Election Day in 1992; the black dashed lines are 95% Newey-West confidence bands. The blue lines show the population coefficients β^{pf} one should obtain under perfect foresight and assuming that the counter-factual path of tax rates under President H. Bush is fixed at $\tau_{1992} = 31\%$. Two scenarios for the path of future tax rates beyond 2011 are shown, one where the W. Bush tax cuts expire in 2011 as scheduled and one where they become permanent. The two vertical lines show the enactment dates of the tax reforms in 2001 and 2003, EGTRRA and JGTRRA respectively.

Figure 6: Path of Expected Tax Rates during presidential election of 2000.



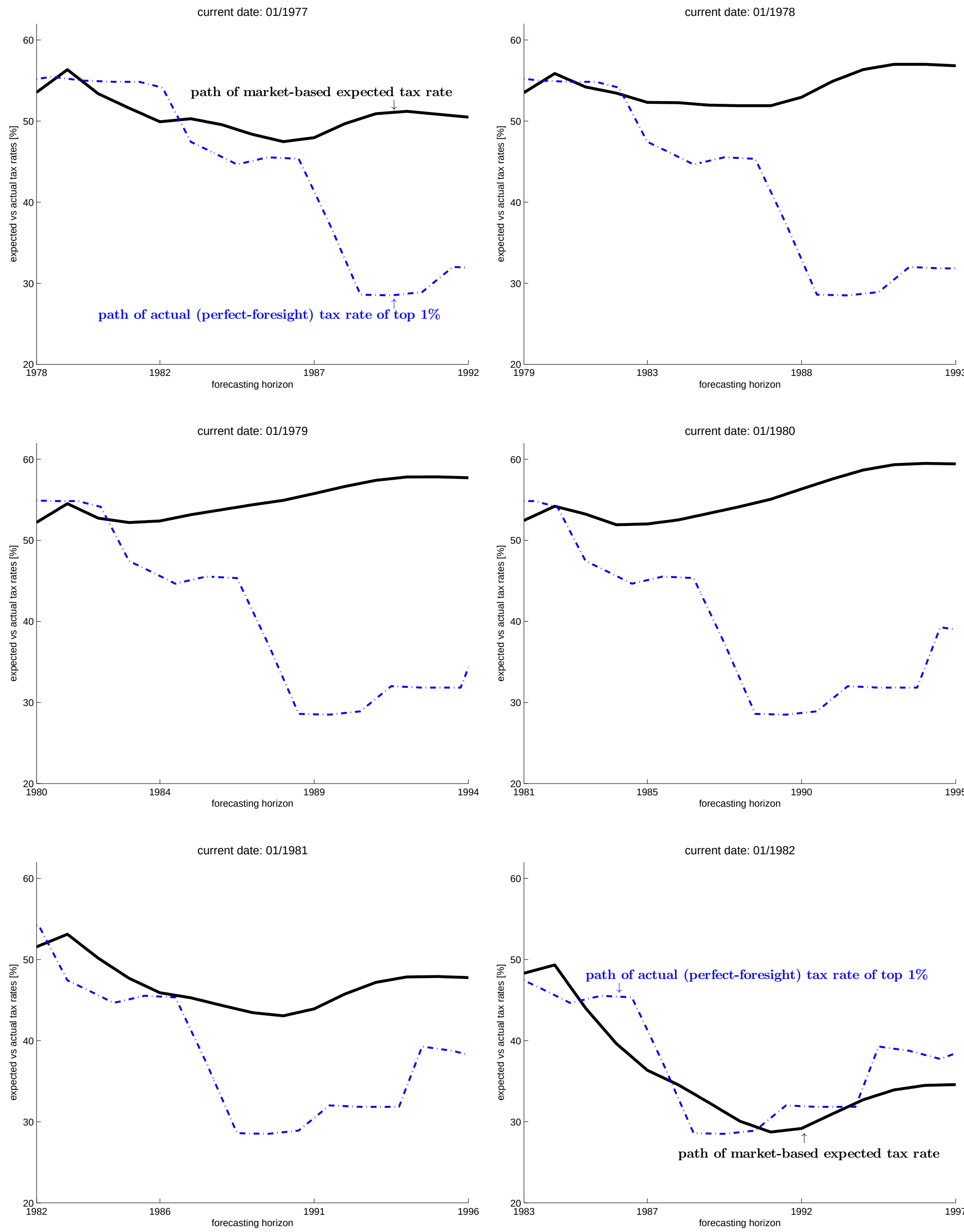
The black line is the expected tax path recovered by inverting equation (6) with a ridge regression with optimal regularization parameter $\mu = 0.15$. The top rate in 2000 is added to the expected changes in the tax path to make it comparable to the ex-post realization of the tax path; see Figure 4 for the definition of the two blue lines.

Figure 7: Path of Expected Tax Rates during presidential election of 1992.



The black line is the expected tax path recovered by inverting equation (6) with a ridge regression with optimal regularization parameter $\mu = 0.05$. The top rate in 1992 is added to the expected changes in the tax path to make it comparable to the ex-post realization of the tax path; see Figure 5 for the definition of the two blue lines.

Figure 8: Anticipation of the Reagan Tax Cuts (ERTA 1981 and TRA 1986) between January 1977 and January 1982.



Notes: This figure shows the evolution of the path of expected tax rates between 1977 and 1982 in the run-up to the first Reagan tax cut (ERTA 1981). The dashed line, which represents the perfect-foresight tax path, is the marginal tax rate of the top 1% of the income distribution taken from Saez (2004). The bond market did not anticipate the Reagan tax cuts until the election year of 1980. However, the bond prices already incorporate the second Regan tax cut (TRA 1986) by the end of 1981. The web appendix of this paper–https://sites.google.com/site/lorenzkueng/–contains a video of the evolution of $\mathbb{E}_t[\tau]$ from January 1977 to August 1982 that shows monthly changes in the path of expected tax rates.

Online Appendix to

"Tax News: Identifying Tax Expectations from Municipal Bonds with an Application to Household Consumption"

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NBER

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1 Data

1.1 Bond Data

Municipal bond yields are taken form two proprietary data sets. The first data set is provided by a large bond data vendor that prefers to remain anonymous. The generic AAA curve is written daily starting in 1983 to represent a fair value offer-side of the highest-grade AAA rated general-obligation state bonds and is determined from trading activity and markets of non-AMT blocks of two million dollars or more. The second municipal bond data set is provided by *Delphis Hanover* and contains yields at weekly frequency between 1976 and 1983.[1] The 30-Day Visible Supply is the total dollar volume of new municipal bonds carrying maturities of 13 months or more that are scheduled to reach the market within 30 days and is taken from the *Bond Buyer: The Daily Newspaper of Public Finance*. The Treasury term-structure is the off-the-run par yield curve taken from Gürkaynak, Sack and Wright (2007). On-the-run Treasury yields and corporate bond yields are taken form the *Board of Governors of the Federal Reserve System, Historical Data Table H.15.*

[1] I loose one year of data by applying the low-pass filter to the time series of break-even tax rates.

1.2 Flow of Funds

The *Flow of Funds* accounts are provided by the *Board of Governors of the Federal Reserve System*. The accounts measure the aggregate stock of assets and liabilities for the financial and non-financial sector as well as the corresponding flows. The statistics can be disaggregated along various dimensions, for instance by ownership.

1.3 Survey of Consumer Finances (SCF)

The *Survey of Consumer Finances (SCF)*, which is provided by the *Board of Governors of the Federal Reserve System*, is conducted every three years and is the most comprehensive source of household wealth in the U.S. The survey has a two sample design; the first sample is a standard geographically based random sample of households, while the second supplemental sample is selected to disproportionately include wealthy families. Therefore, the choice of sampling weights is important to infer population parameters. However, the SCF supplies alternative sets of sampling weights in some years. In choosing the sampling weights I follow Wolff (2010) who minimizes the discrepancy between national balance sheet totals derived from the SCF and corresponding values from the Federal Reserve Board Flow of Funds. For the 1983 SCF I use the 'Full Sample 1983 Composite Weights' (b3005) and for the 1989 SCF I use the average of the SRC-Design-S1 series (x40131) and the SRC design-based weights (x40125). From 1995 on I use the design-based weights (x42000 for 1995 and x42001 from 1998 on) which is a partially design-based weight constructed on the basis of original selection probabilities and frame information, adjusted for non-response. In the case of the 1992 SCF, these weights produce major anomalies in the size distribution of income for 1991. As a result, I modify the weights to conform to the size distribution of income as reported in the IRS Statistics of Income and as recommended by Wolff (2010). In particular, I adjust the 1992 weights to conform to the 1989 weighting scheme. The adjustment factors for the 1992 weights are given by the inverse of the normalized ratio of weights between 1992 and 1989 and shown in the following table.

Adjusted Gross Income (AGI) in 1989	Adjustment Factors for 1992 Weights
$\text{AGI} < 200,000$	0.992
$200,000 \leq \text{AGI} < 1,000,000$	1.459
$1,000,000 \leq \text{AGI} < 4,000,000$	1.877
$4,000,000 \leq \text{AGI} < 7,000,000$	4.844
$\text{AGI} \geq 7,000,000$	12.258

Bonds include direct and indirect holdings, and whenever possible I use market values of bonds and face values otherwise. Direct ownership of taxable bonds includes 'face amount of other taxable/corporate bonds and foreign bonds' (b3461,x3912), 'market or face value of Treasury bonds' (b3459, x3908, x7636), 'market or face value of mortgage-backed bonds' (x3906, x7635), 'market value of other taxable bonds' (x7639), 'market value of foreign bonds' (x7638), and 'market value of all bonds not listed otherwise' (x6706). Indirect holdings of taxable debt include 'dollar amount of shares in taxable mutual funds' (b3464), 'market value of Treasury bond mutual funds' (x3826), and 'market value of other taxable bond mutual funds' (x3828). Direct ownership of tax-exempt bonds includes 'market or face value of tax-free bonds' (b3460, x3910, x7637). Indirect holdings of tax-exempt debt includes 'dollar amount of shares in tax-free mutual funds' (b3463) and 'market value of tax-free bond mutual funds' (x3824).

1.4 Election Probabilities

Election probabilities are based on the winner-takes-all market of the *Iowa Electronics Markets (IEM)*. The IEM is an on-line futures market operated by *University of Iowa Henry B. Tippie College of Business School*. All interested participants world-wide can trade in the political markets, and bets are limited to \$500. The payoff of the contract is determined by which of the nominees receive the biggest share of the popular vote cast. Contracts associated with nominees that do not receive the bigger number of popular votes in the election will pay off \$0; contracts associated with the nominee that receives the bigger number of popular votes will pay off \$1. I use last price quotes of the winner-takes-all contracts which reflect the price of the last trade before midnight. 'Last prices' ensure a close relationship between the information in the prices of the betting contracts and the bond prices, which also reported at the end of the trading day.

1.5 Consumer Expenditure Survey (CEX)

The *Consumer Expenditure Survey (CEX)*, which is provided by the *Bureau of Labor Statistics (BLS)*, is the most comprehensive data source on household consumption in the U.S. This paper uses the raw data of the interview survey, which can be accessed from the *Interuniversity Consortium for Political and Social Research (ICPSR)* at the *University of Michigan*. The CEX is a monthly rotating panel and each household (i.e. consumer unit) is interviewed once per quarter, for at most five consecutive quarters, although the first interview is used for pre-sampling purposes and is not available for analysis. In each interview the reference period for expenditure covers the three months prior to the interview month. However, the within-interview variation is much lower than the between-interview variation, suggesting that many households provide average monthly expenditures instead. Therefore, I aggregate the expenditures to quarterly expenditures. Income data is asked in the first and last interview (i.e. interviews 2 and 5 in CEX terminology), and financial data is only asked in the last interview. The reference period for income flows covers the twelve month before the interview. All nominal variables are deflated using the CPI-U.

I impute taxes with the NBER TAXSIM calculator using an iterative procedure to determine the itemization status of each household and to account for deductions that depend on the household's AGI; for example health-care or job expenses. The code is available at www.nber.org/

~taxsim/to-taxsim/cex-kueng/cex.do. I compute perfect-foresight average tax rates $\{\bar{\tau}_{i,t+s}\}_{s=0}^{M}$ for each household i in the CEX that depend on the head of household's age and the household's predetermined income percentile. These profiles allow for predictable changes in average tax rates due to the hump shape of the life-cycle income profile. Predetermined income and household age are good predictors of future household income. I confirm this conjecture in independent work in which I extend the income imputation model of the BLS for the CEX, which started in 2004, back to 1980. Predetermined income and household age are the best predictors of future levels of household income. Other studies also found that household income dynamics are well approximated by a random walk after controlling for the age profile of income, e.g., MaCurdy (1982), Abowd and Card (1989), and Meghir and Pistaferri (2004). Predetermined income summarizes observed household characteristics such as education and experience as well as unobserved heterogeneity such as work effort. Household age has predictive power for future income even conditional on work experience. I estimate future average tax rates non-parametrically; in particular, I discretize the joint distribution of age and income and assume that the household remains in the same age-specific income percentile throughout its life-cycle.[2] Having only two dimensions guarantees that there is a sufficient number of households in each age-income cell in each year, i.e., at least 20. I restrict the sample to households where the head's age is between 25 and 65 years and the head is not a student–a sample selection that is common in most studies that use the CEX; see for example, Souleles (1999), and Johnson, Parker and Souleles (2006). I use households age 65 to 75 to estimate counter-factual retirement income after age 65. I use the tax code of 2004 to compute perfect-foresight average tax rates for years 2005 to 2011 after which I assume that the Bush tax cuts expire. This assumption is supported by the bond markets' expectations during the presidential election of 2000. I use the tax code of 2000–the last year under Clinton–to calculate perfect-foresight average tax rates beyond the year 2011. I assume that households expect to receive this level of retirement income for the rest of the planning period. I limit the estimation of the retirement period to households age 65 to 75 due to the fact that the quality of the survey answers tends to be poorer for old retirees.

I follow the literature and exclude housing services, health care and health insurance, and education services from the definition of nondurables and services, since these expenditures have characteristics of durable goods. I correct sample breaks due to slight changes in the questionnaire of the following variables: food at home ('82Q1-'88Q1), personal care services ('01Q2), occupation expenditures ('01Q2), and property taxes ('91Q1). As recommended by the BLS, I sum expenditures that occur in the same month but are reported in different interviews. In addition to the sample selection mentioned in the text, I drop the following cases: interviews with more or less than three monthly observations; households with zero food or total expenditures; non-consecutive interviews; observations with negative expenditures where there should not be any; households with

[2] More precisely, I use the following income percentile thresholds: $10, 20, \ldots, 50, 55, \ldots, 95$. I use a finer grid for higher incomes to better account for the increasing income inequality during the sample period. I use age bins with a 10-year range to make sure that the number of observations in each cell is at least 20. The five age bins–age 25-34, 35-44, 45-54, 55-64, 65-75–approximate the income life-cycle profiles well.

more than one consumer unit; households for which the family size changes by more than three (e.g. Johnson et al. (2006)); households for which the age of any member increases by more than one or decreases (e.g. Souleles (1999)); and households with negative liquid wealth; households with positive business or farm income; and student housing or household heads that are students.

2 Bond Defaults

2.1 The Markets for Treasury and Municipal Bonds

Both the Treasury and municipal bond markets are deep. During the period 1980 to 2001, Treasury debt has a share between 16 and 32% of all outstanding U.S. marketable debt while the share of municipal debt is between 9 and 19%. To put these numbers in perspective, the total volume of marketable US debt was $18.5 trillion in 2001.[3]

2.2 Historical Bond Default Rates

Table 2 provides historical default rates for municipal bonds by credit rating. Corporate bond default rates are shown for the sake of comparison. Two facts stand out: first, AAA rated municipal debt is indeed essentially default-risk free; and second, the credit ratings for municipal and corporate bonds are not comparable. For instance, municipal bonds that are rated only BBB have a lower in-sample default rate than AAA rated corporate bonds. The two rating scales are therefore not comparable.

2.3 Pre-Refundend Municipal Bonds and Rare Default Events

The historical analysis of defaults on general-obligation state bonds provides strong evidence that credit risk is not a main driver of the municipal yield spread. However, it is conceivable that rare default events nevertheless affect municipal bond prices, even tough such events have not yet realized in-sample. It is difficult to quantify the effect of such rare events without having a very long time series of bond prices. This and the next section provide additional evidence that the effect of such rare events on the municipal yield spreads is small.

Figure 2 shows the yield difference between AAA general-obligation and pre-refunded municipal bonds. A municipality can refinance older debt if it has sufficient funds – either through revenue or by issuing new debt –, for example to take advantage of lower interest rates. The municipality invests these funds in Treasuries or special State and Local Government Securities (SLUGS), which are issued by the Treasury, and deposits them in an escrow account at the Treasury Department. The interest on these Treasury securities is then used to pay the interest on the now pre-refunded municipal debt. Since pre-refunded municipal bonds are escrowed and invested in Treasury securities they bear essentially the same default risk as Treasury bonds. Pre-refunded municipal bonds should

[3] These calculations are based on data from the Securities Industry and Financial Markets Association (SIFMA), http://www.sifma.org/research/statistics.aspx.

therefore offer lower yields than similar AAA general-obligation municipal bonds in the absence of any other risk. However, pre-refunded municipal bonds are less frequently issued and traded and are therefore less liquid. The pre-refunded municipal yield spread supports the conclusions from Table 2, showing that the liquidity premium outweighs the default risk premium over the available sample period.[4] The yield spread is very small and the default risk premium of AAA general-obligation bonds is therefore also small. This finding is consistent with a similar exercise reported in Chalmers (1998).

2.4 State CDS Spreads

Credit Default Swaps (CDS) on municipal debt are a more recent financial innovation that offers an alternative way of measuring expected default risk. However, one is confronted with several issues when inferring default risk from CDS spreads. First, data of CDS spreads on municipal bonds is available only starting in 2005. Second, CDS contracts on state bonds with a AAA rating are traded very infrequently, most likely due to the low hedging demand for such a rare credit event. Third, CDS spreads are often dominated by liquidity and counter-party risk; see for example Giglio (2011).

Figure 3 shows CDS spreads for Treasury bonds, for AAA rated municipal state bonds from Maryland, and (for comparison) the spread on AAA rated corporate bonds issued by Berkshire Hathaway, one of only a few corporations that until recently were rated AAA from the beginning. Figure 3 highlights both the low liquidity of the municipal CDS and the low premium of such contracts relative to Treasury CDS in times when trading activity is high. The CDS spreads therefore also support the conclusions in this paper.

3 Details on the Tax Reforms in the Sample

3.1 Average Tax Rate Changes

Figure 4 shows the changes in the average tax rate as a function of taxable income for all major income tax reforms in my sample. To generate these profiles I use a distribution of incomes with equally spaced grid points of $100 increments. I feed this income distribution into the TAXSIM calculator and assume that the households are married, file jointly, and have no children. For example, Figure 5(a) shows the change in average tax rates caused by the first Reagan tax cut (ERTA 1981) as a function of taxable income. The tax cuts were phased-in over three years from 1981 to 1983. The thick black line shows the total change by comparing the average tax rate after the reform in 1984 with the average tax rate before the reform in 1980. Figure 5(a) emphasizes the fact that households were affected differently by the income tax changes depending on the taxable income.

The average tax rates imputed in the CEX have more variation than Figure 4 suggests. This ad-

[4] Yields on pre-refunded municipal bonds are available only from 1993 on. Moreover, the data set contains only few maturities for those bonds. For these reasons and because pre-refunded yields are higher than AAA general-obligation bonds I use the latter to construct the spread between Treasury and municipal yields.

ditional variation comes from the fact that different households have different family characteristics, such as the number of children and dependents or the marital status, as well as different deductions, exemptions, and tax credits. The CEX provides a rich set of household characteristics that allows me to compute household specific tax rates. The only main input variables used by TAXSIM that are missing from the CEX are short- and long-run capital gains. The fact that changes in the average tax rate are not constant as a function of taxable income provides identifying variation in the cross-section when I control for monthly fixed effects.

3.2 Changes in the Tax Base

Tax reforms can affect not only the tax rates but also the tax base. Since the effect of a tax reform on the after-tax lifetime income is a combination of changes in the tax rates and the tax base, it is useful to analyze changes in the tax base over the sample period more closely. Most tax reforms since 1980 affected the income tax base only modestly, with the exception of the Tax Reform Act of 1986 (TRA 1986). Auerbach and Slemrod (1997) discuss this tax reform in detail, showing that the reduction in income tax revenue was compensated by widening the base of the corporate tax and closing loopholes in the tax code. Although the incidence of the corporate tax is difficult to assess, it is clear that closing tax loopholes affects mainly very high-income households, in particular those who have flexibility in changing the composition of their taxable income, such as self-employed households and business owners. The sample used in this paper excludes self-employed households and the CEX tends to under-samples very rich households. Since both groups are affected the most from the offsetting extension of the tax base, it is likely that most high- and middle-income households in the sample benefited from the tax reform, even though the TRA 1986 might have been roughly revenue neutral in the aggregate.[5] Nevertheless, since Auerbach and Slemrod conclude that "the effects of the [Tax Reform] Act on saving are more difficult to identify because of the many confounding influences of the period and our greater uncertainty about the proper modeling of the savings decision," I test the robustness of the result using different time sub-periods in the robustness section of the main paper.

4 Robust Inverse

The solution to the constrained least squares problem of the inverse mapping $\beta = \mathbb{E}[W_t](\mathbb{E}[\tau|\text{Bush}] - \mathbb{E}[\tau|\text{Gore}])$ is

$$\begin{aligned} \mathbb{E}[\tau|\Delta\text{Bush}] &= \arg\min_x \left\{ ||\mathbb{E}[W_t]x - \hat{\beta}||^2 \ : \ ||\partial x||^2 \leq \varepsilon \right\} \\ &= \left(\mathbb{E}[W_t]'\mathbb{E}[W_t] + \mu\, \partial'\partial\right)^{-1} \mathbb{E}[W_t]'\hat{\beta}. \end{aligned} \tag{1}$$

[5] Many lower-income households faced an increase in tax liabilities as a result of the tax reform; see for example Hausman and Poterba (1987).

∂ is either the identity matrix (basic ridge regression) or the $(M-1)$-by-M first difference operator (first-order ridge regression). Similarly, the ridge regression to the inverse problem $\tilde{\theta}_t = W_t \mathbb{E}_t \tau - \Lambda_t$ is

$$\begin{aligned} \mathbb{E}_t \tau &= \arg\min_x \left\{ ||W_t x - (\tilde{\theta}_t + \mathbb{E}[\Lambda_t])||^2 \ : \ ||\partial x||^2 \leq \varepsilon \right\} \\ &= \left(W_t' W_t + \mu \ \partial' \partial\right)^{-1} W_t (\tilde{\theta}_t + \mathbb{E}[\Lambda_t]) \ . \end{aligned} \tag{2}$$

To obtain a better intuition of how the regularization works it is useful to analyze the solution using the generalized singular value decomposition. Since $\mathbb{E}_t[W_t]$ and ∂ have full rank and the null spaces of both matrices intersect only at the zero vector, there exist matrices U, V, Π, Ξ, Y such that U is orthonormal, Y is nonsingular, Π is diagonal with decreasing diagonal elements $1 \geq \pi_i \geq \ldots \geq \pi_m \geq 0$, and Ξ is diagonal with increasing elements $0 < \xi_1 \leq \ldots \leq \xi_M \leq 1$ (see Aster, Brochers and Thurber (2005)). ξ_m and π_m are normalized such that $\xi_m^2 + \pi_m^2 = 1 \ \forall \ m$. The generalized singular values are defined as $\gamma_m = \frac{\pi_m}{\xi_m}$. The matrices U, V, Π, Ξ, Y are related to the *two* matrices $\mathbb{E}_t[W_t]$ and ∂ (hence the name *generalized* singular value decomposition) as follows:

$$\mathbb{E}_t[W_t] = U \begin{bmatrix} \Pi & 0 \\ 0 & I \end{bmatrix} Y^{-1} \ ,$$

$$\partial = V \ [\Xi \ \ 0] \ Y^{-1} \ ,$$

$$\left(\mathbb{E}_t[W_t] Y\right)' \left(\mathbb{E}_t[W_t] Y\right) = \begin{bmatrix} \Pi^2 & 0 \\ 0 & I \end{bmatrix} \ ,$$

$$\left(\partial Y\right)' \left(\partial Y\right) = \begin{bmatrix} \Xi^2 & 0 \\ 0 & 0 \end{bmatrix} \ .$$

One can show that the robust inverse solution $\mathbb{E}_t \tau$ can be written as

$$\mathbb{E}_t \tau = \sum_{m=1}^{M} \underbrace{\frac{\gamma_m^2}{\gamma_m^2 + \mu}}_{\text{filter } f_m} \underbrace{\frac{u_m' (\tilde{\theta}_t + \mathbb{E}[\Lambda_t])}{\pi_m} y_m}_{\text{direct inverse}} \ , \tag{3}$$

where u_m is the m-th column vector of matrix U and y_m is the m-th column vector of matrix Y. There are two important facts to take away from this equation. First, the fraction $f_m = \gamma_m^2/(\gamma_m^2 + \mu)$ is a filter factor that stabilizes the inverse solution. Small singular values π_m and hence small generalized singular values γ_m are dampened ($f_m \ll 1$) while large singular values are less affected ($f_m \approx 1$). If $\mu = 0$, then $f_m = 1 \ \forall \ m$ and equation (3) reduces to the direct inverse (respectively to the singular value decomposition of the inverse of $\mathbb{E}_t[W_t]$). Second, since $\mathbb{E}_t[W_t]$ is a lower triangular weighting matrix, the generalized singular values are naturally decreasing in the maturity m, i.e.

they are decreasing in m without having to rearrange the columns or rows of $\mathbb{E}_t[W_t]$. Moreover, for maturities up to around 10 years, $\gamma^2 \gg \mu$ and hence $f \approx 1$. Therefore, the regularization affects the solution $\mathbb{E}_t\tau$ only for larger maturities and longer forecasting horizons.

Note that the value of μ does not substantially affect the size of the tax news shocks over reasonable ranges. This robustness is due to the fact that computing the expected after-tax lifetime income over 30 years does smooth much of the 'excess volatility' of $\mathbb{E}_t\tau$ caused by the ill-posed inverse problem. Moreover, the forward tax rates that are affected the most by the choice of μ are long-run forecasts. These expected long-run tax rates receive much less weight in the calculation of the expected after-tax lifetime income, which is an annuity value and hence discounts more distant values more heavily.

There are two main criteria in the literature for choosing μ. The first is a heuristic, but more robust criterion called the L-curve approach. The other is based on generalized cross validation (GCV). GCV has a number of desirable statistical properties if the error term is independently and identically distributed, but tends to under-smooth if errors are correlated. Liquidity shocks are not uncorrelated across maturities. A liquidity shock that affects for example the 20-year maturity also affects the maturities at 19 and 21 years. Otherwise, there would be opportunities for maturity-based arbitrage. The L-curve approach on the other hand is not guaranteed to converge and is computationally expensive. I therefore calculate the optimal μ for a number of periods using both approaches. The optimal μ is on average about 0.01 for these dates and does not vary much. Hence, I set $\mu = 0.01$ globally to calculate $\mathbb{E}_t\tau$ for the entire sample from 1977 to 2001. Moreover, I use a separate optimal μ for the two election periods to calculate $\mathbb{E}[\tau|\Delta\text{Bush}]$ and $\mathbb{E}[\tau|\Delta\text{Clinton}]$ since the inversion problem of the regression coefficients has different statistical properties and hence a different optimal value of μ.

5 Relation to the Empirical Finance Literature

This paper also contributes to a large literature in empirical finance that analyzes the determinants of the municipal yield spread. Using data mostly from the 1960s and 1970s, Fama (1977) identifies the corporate tax rate as the fundamental determinant of the municipal yield spread. Later studies, such as Fortune (1996), Green (1993), Kochin and Parks (1988), Poterba (1986), Park (1995) and many others find the individual income or capital gains tax rate to be an important explanation of the spread. I contribute to this literature in two ways. First, I identify the marginal investor for an important class of assets and show that the disagreement about the fundamental determinants of the municipal yield spread are most likely due to changes in the marginal investor over time. While high-income households appear to be the marginal investors since the late 1970s, bank corporations were probably the marginal investors in the 1960s and early 1970s.[6] Second, I show that economic fundamentals explain most of the variation in the municipal yield spread

[6] This paper focuses on bonds with maturities of at least one year. It is possible that the marginal investor is different at the very short end of the term structure.

over long horizons, while liquidity or discount rate shocks are important in the short run. Previous studies that found changes in tax rates to be important determinants of changes in the municipal yield spread include Mankiw and Poterba (1996), Slemrod and Greimel (1999), and Ayers, Cloyd and Robinson (2005).

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Table 1: Summary statistics for CEX sample.

Variable	N	Mean	Std. Dev.	p1	p10	p50	p75	p90	p99
Tax news shock [in %]	107136	-0.02	0.41	-1.18	-0.55	0.00	0.22	0.44	0.95
BP residual of news shock*	107136	-0.01	1.83	-5.04	-2.12	0.00	0.91	1.92	5.07
Average tax rate	107136	16.02	7.26	0.00	0.00	15.77	20.36	23.72	30.94
Federal AGI [in 1982-84]	107136	28.57	24.29	0.00	4.39	24.86	38.39	53.16	108.56
Number of earners	107136	1.56	0.90	0	1	2	2	3	4
Age of reference person	107136	43.07	11.44	25	29	41	52	60	65
Family size	107136	2.81	1.49	1	1	3	4	5	7
Δ adults	107136	0.01	0.25	-1	0	0	0	0	1
Δ kids	107136	0.00	0.20	-1	0	0	0	0	1
Nondurable consumption growth [in %]	107136	50.45	12265.82	-297.58	-15.24	0.06	5.60	15.43	310.49
Nondurable consumption growth, winsorized	107136	0.09	8.77	-14.93	-14.93	0.06	5.60	15.12	15.12

	Fraction [%]		Fraction [%]
Education:**		Tax filer status:	
- no school	0.13	- single filer	25.10
- high school dropout	16.40	- joint filer	60.88
- high school	31.77	- head of household	14.02
- college dropout	21.84		
- college	18.22	Composition of earners:	
- graduate school	11.64	- reference person only	34.82
		- reference person and spouse	29.99
Marital status:		- reference person, spouse and others	8.49
- married	61.22	- reference person and others	10.78
- widowed	5.20	- spouse only	3.26
- divorced	15.58	- spouse and others	1.00
- separated	4.44	- others	2.01
- never married	13.56	- no earners	9.64

Notes: (*) BP stands for band-pass filter; (**) education is the maximum level of education achieved by the reference person and the spouse. All statistics use sampling weights.

Table 2: Historical bond default rates 1970-2006 [in %]

Rating categories	Municipal Bonds		Corporate Bonds	
	Moody's	S&P	Moody's	S&P
Aaa/AAA	0	0	0.52	0.6
Aa/AA	0.06	0	0.52	1.5
A/A	0.03	0.23	1.29	2.91
Baa/BBB	0.13	0.32	4.64	10.29
Ba/BB	2.65	1.74	19.12	29.93
B/B	11.86	8.48	43.34	53.72
Caa-C/CCC-C	16.58	44.81	69.18	69.19
Investment Grade	0.07	0.2	2.09	4.14
Non-Investment Grade	4.29	7.37	31.37	42.35
All	0.1	0.29	9.7	12.98

Source: Moody's and S&P, taken from Representative Barney Frank's request to accompany the Municipal Bond and Fairness Act H.R. 6308, September 9 2008, accessed on 4/7/2010 via http://frwebgate.access.gpo.gov.

Table 3: Presidential election of 2000 – full results with controls.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Break-Even Tax Rate (BETR) :	1-Year	2-Year	3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
Price of Bush Contract [in cents]	0.018	-0.018***	-0.031***	-0.033***	-0.028***	-0.024**	-0.006	0.003
	(0.013)	(0.007)	(0.007)	(0.007)	(0.010)	(0.011)	(0.009)	(0.013)
Aa - PreRefunded Muni Spread	1.009***	1.642**	1.881**	1.853***	1.547**	1.723**	1.545***	1.412***
	(0.368)	(0.653)	(0.745)	(0.685)	(0.676)	(0.684)	(0.538)	(0.521)
Baa - Aa Muni Credit Spread	45.714*	70.790***	64.072**	72.711**	70.000**	66.131*	43.131	39.578
	(25.107)	(25.518)	(29.681)	(31.518)	(35.275)	(38.728)	(27.520)	(27.873)
Muni Supply - negotiated offer [in billions]	-0.012	-0.072	-0.046	-0.098	-0.037	0.002	0.024	0.052
	(0.107)	(0.145)	(0.158)	(0.152)	(0.156)	(0.168)	(0.140)	(0.164)
Muni Supply - competitive offer [in billions]	-0.118	-0.064	-0.092	0.013	0.048	0.028	0.064	0.028
	(0.135)	(0.275)	(0.316)	(0.282)	(0.270)	(0.267)	(0.217)	(0.221)
Repeated Muni Prices [weekly]	-0.122	-0.014	-0.056	-0.032	0.038	0.052	0.069	0.072
	(0.185)	(0.220)	(0.272)	(0.284)	(0.311)	(0.312)	(0.246)	(0.266)
Repeated Muni Price Indicator	0.004	-0.028	0.010	-0.011	-0.006	0.017	0.009	-0.004
	(0.067)	(0.068)	(0.088)	(0.076)	(0.092)	(0.099)	(0.074)	(0.056)
Corporate Spread	54.887***	8.446	15.226	11.989	8.959	12.871	13.644	22.906
	(15.206)	(22.187)	(24.320)	(22.445)	(20.789)	(22.593)	(21.815)	(18.571)
Off- vs. On-the-Run Treasury Spread	-63.866	-77.407*	-79.689	-51.131	-91.298	-139.131**	-132.473**	-49.077
	(47.887)	(45.995)	(51.205)	(49.492)	(55.131)	(66.687)	(52.346)	(58.971)
StDev of 10-Year Treasury [weekly]	3.105	6.582***	7.453***	6.972***	7.280***	7.105***	6.260***	5.875**
	(1.891)	(2.080)	(2.329)	(2.162)	(2.456)	(2.697)	(2.371)	(2.301)
Volume in Prediction Market [in cents]	-0.006	-0.003	-0.002	-0.002	-0.014	-0.020	-0.024	-0.017
	(0.025)	(0.017)	(0.017)	(0.019)	(0.021)	(0.022)	(0.015)	(0.022)
Units Traded in Prediction Market	-0.189	-0.134	-0.156	-0.124	-0.115	-0.106	-0.045	-0.088
	(0.119)	(0.108)	(0.123)	(0.111)	(0.105)	(0.105)	(0.082)	(0.086)
Observations	131	131	131	131	131	131	131	131
Treasury yields	YES	YES	YES	YES	YES	YES	YES	YES
Month FE; day FE; time trend	YES	YES	YES	YES	YES	YES	YES	YES

Notes: This table shows the full results from regressing daily election probabilities on break-even tax rates for the presidential election of 2000. The tax reform enacted in 2001 (EGTRRA 2001) reduced the statutory top income rate by 4.6% from 39.6% to 35% over 5 years and the reform in 2003 (JGTRRA 2003) accelerated the phase-in period to three years. The contracts yield 100 cents if the candidate wins and zero otherwise. Therefore, an increase of the price by 1 cent corresponds to a 1% increase in the perceived probability of the candidate winning the presidential election. Newey-West HAC robust standard errors in parentheses: ***, **, * mark significance at the 1, 5, and 10 percent level, respectively.

Table 4: Presidential election of 1992 – full results with controls.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Break-Even Tax Rate (BETR) :	1-Year	2-Year	3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
Price of Clinton Contract [in cents]	0.140***	0.096**	0.140***	0.091***	0.097***	0.103***	0.042***	0.047**
	(0.048)	(0.047)	(0.040)	(0.026)	(0.022)	(0.021)	(0.015)	(0.018)
Aa - PreRefunded Muni Spread	0.262	0.110	0.142	0.038	0.020	-0.076	-0.027	-0.024
	(0.299)	(0.124)	(0.114)	(0.097)	(0.081)	(0.098)	(0.071)	(0.071)
A - Aa Muni Credit Spread	0.213	-0.270	-0.296	-0.193	-0.260	-0.247	-0.334**	-0.283*
	(0.514)	(0.314)	(0.319)	(0.264)	(0.262)	(0.213)	(0.135)	(0.163)
Muni Supply - negotiated offer [in billions]	0.014	-0.399**	-0.417**	-0.276**	-0.266**	-0.227**	-0.071	-0.073
	(0.292)	(0.187)	(0.186)	(0.136)	(0.113)	(0.098)	(0.086)	(0.092)
Muni Supply - competitive offer [in billions]	-1.549*	0.024	0.123	0.224	0.134	0.050	0.164	0.082
	(0.869)	(0.587)	(0.537)	(0.446)	(0.429)	(0.399)	(0.183)	(0.162)
Repeated Muni Prices [weekly]	-0.715	-1.054	-0.497	-0.662	-0.737	-0.944	0.066	0.244
	(0.931)	(0.669)	(0.610)	(0.722)	(0.661)	(0.612)	(0.281)	(0.466)
Repeated Muni Price Indicator	0.614	0.744***	0.648***	0.469***	0.449***	0.371***	0.229*	0.218*
	(0.423)	(0.222)	(0.161)	(0.135)	(0.135)	(0.134)	(0.121)	(0.112)
Corporate Spread	175.343	201.013	193.444	158.724	172.348**	100.154	57.735	90.414**
	(218.585)	(139.365)	(124.891)	(107.684)	(84.835)	(70.139)	(54.392)	(43.992)
Off- vs. On-the-Run Treasury Spread	-181.591	63.929	-60.848	28.947	-4.916	-58.666	27.482	39.941
	(150.429)	(96.640)	(106.422)	(83.314)	(73.493)	(76.263)	(50.566)	(61.762)
StDev of 10-Year Treasury [weekly]	-7.101	-0.315	3.454	7.004**	8.289***	6.507**	-0.747	-0.846
	(7.352)	(3.669)	(3.407)	(3.138)	(3.048)	(2.963)	(1.912)	(2.478)
Volume in Prediction Market [in cents]	0.177	0.321	0.067	-0.004	-0.043	-0.085	-0.006	0.092
	(0.449)	(0.311)	(0.306)	(0.211)	(0.244)	(0.220)	(0.151)	(0.161)
Units Traded in Prediction Market	-1.735	-2.383	-0.246	0.274	0.460	0.773	0.094	-0.725
	(3.880)	(2.608)	(2.567)	(1.773)	(1.994)	(1.807)	(1.231)	(1.316)
Observations	82	82	82	82	82	82	82	82
Treasury yields	YES	YES	YES	YES	YES	YES	YES	YES
Month FE; day FE; time trend	YES	YES	YES	YES	YES	YES	YES	YES

Notes: This table shows the full results from regressing daily election probabilities on break-even tax rates for the presidential election of 1993. The tax reform enacted in 1993 (OBRA 1993) increased the statutory top income rate by 8.6% from 31% to 39.6% retroactively to January 1, 1993. The contracts yield 100 cents if the candidate wins and zero otherwise. Therefore, an increase of the price by 1 cent corresponds to a 1% increase in the perceived probability of the candidate winning the presidential election. Newey-West HAC robust standard errors in parentheses: ***, **, * mark significance at the 1, 5, and 10 percent level, respectively.

Figure 1: Average break-even tax premium $\mathbb{E}[\Lambda_t]$ as a function of the maturity.

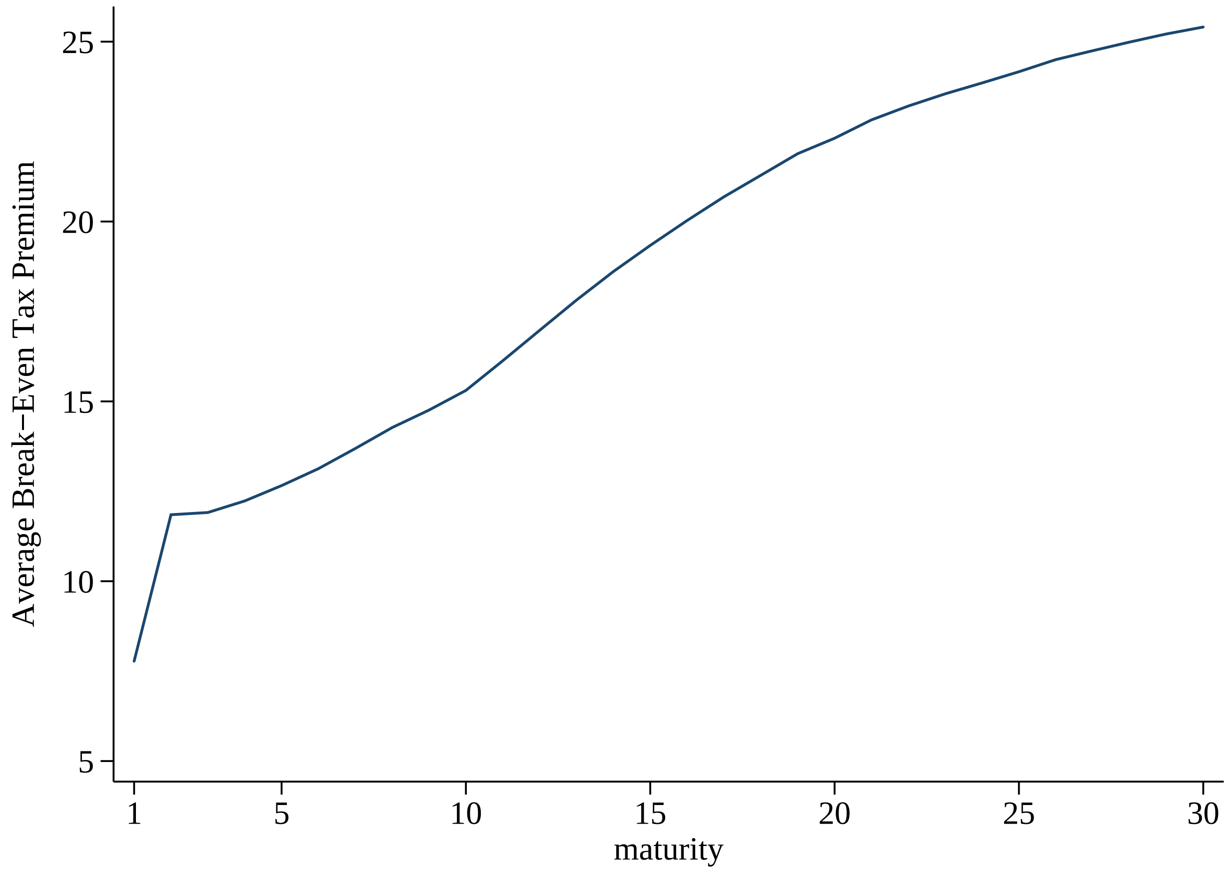


Figure 2: Spread between AAA general-obligation and pre-refunded municipal bonds with 7-year maturity.

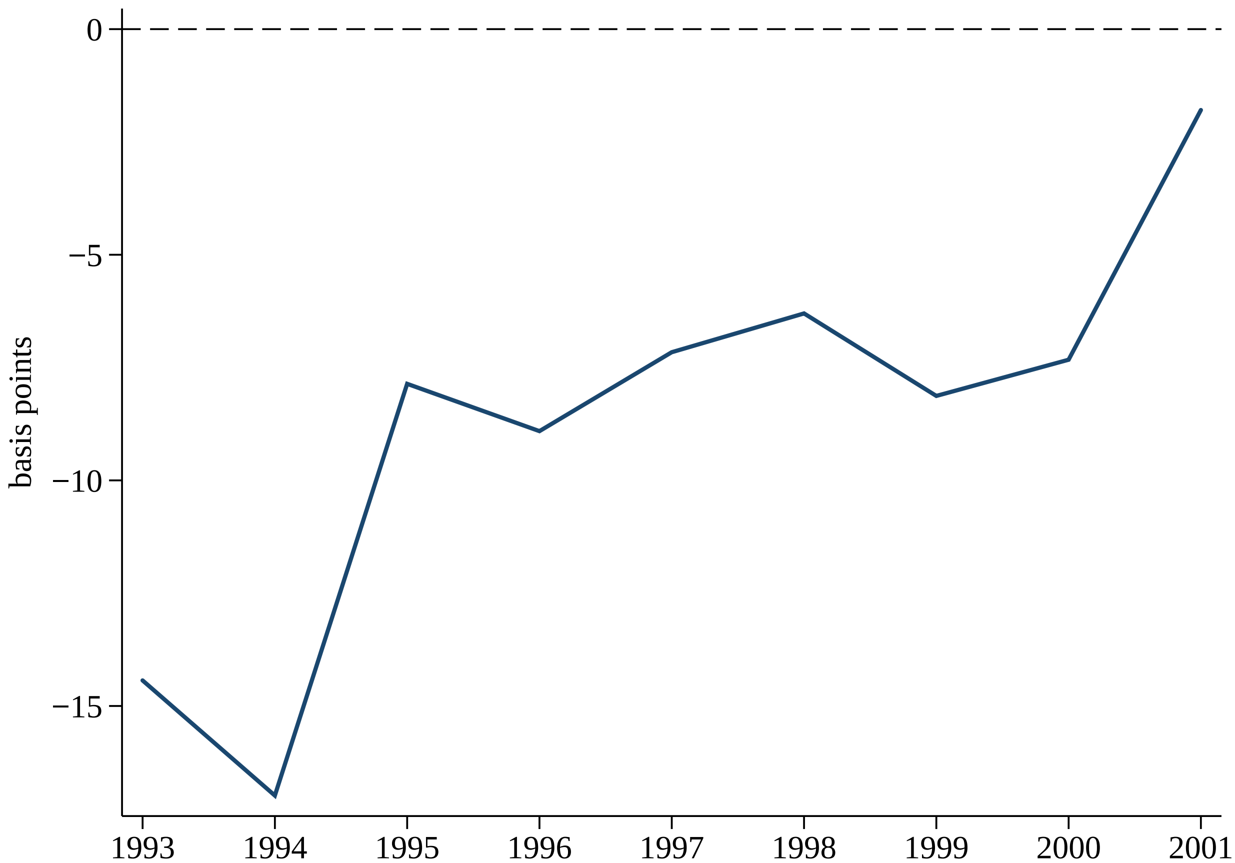
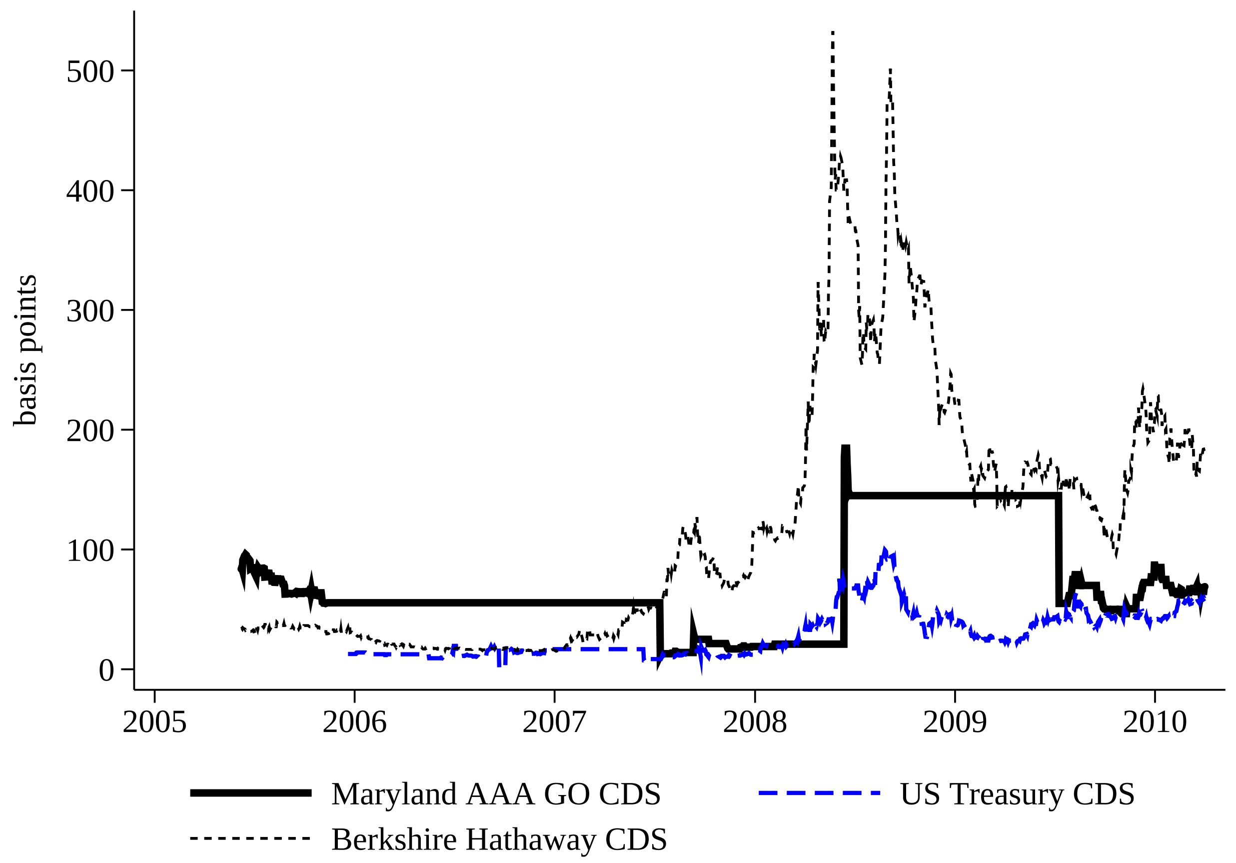
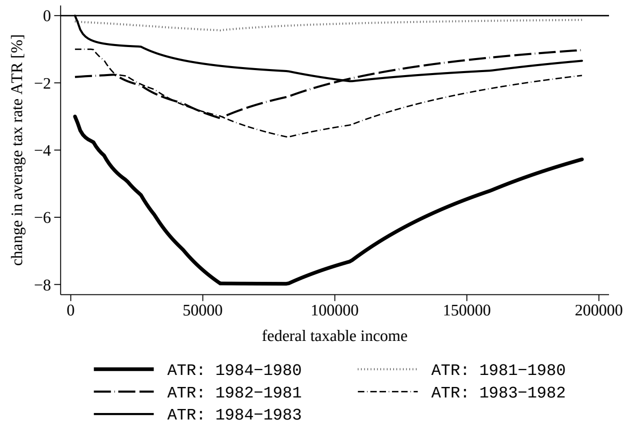


Figure 3: Credit Default Swap (CDS) of 10-year Treasury, municipal, and corporate bonds.

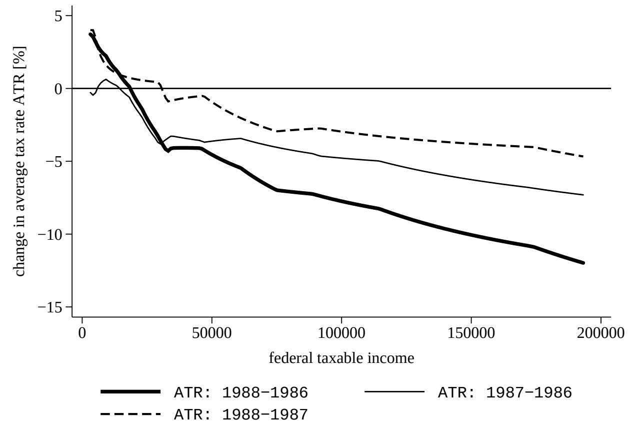


Source: Credit Market Analysis (CMA) taken from Datastream.

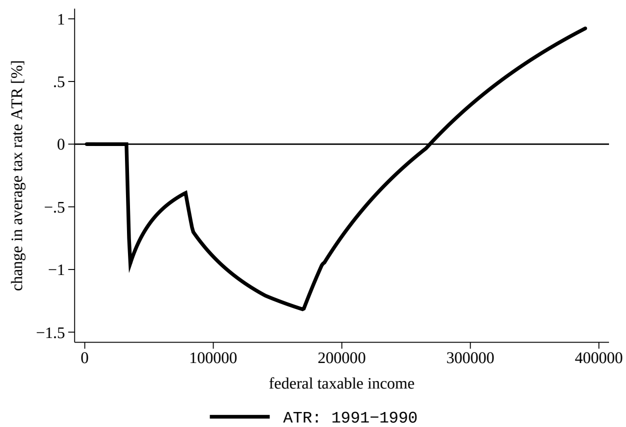
Figure 4: Change in the average tax rate caused by income tax reforms between 1980 and 2003.



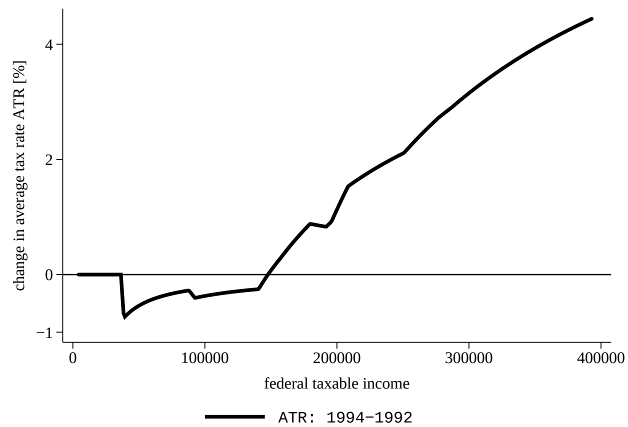
(a) ERTA 1981



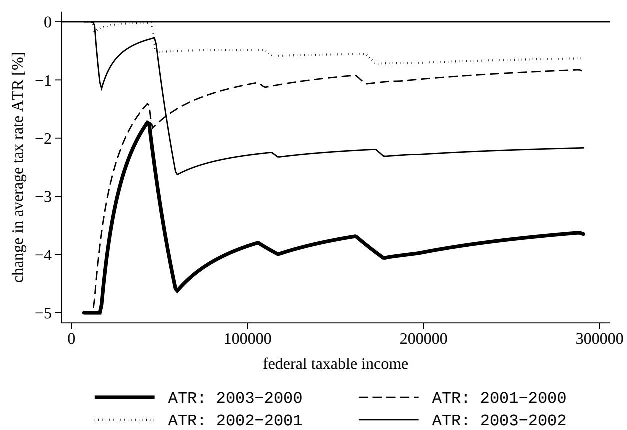
(b) TRA 1986



(c) OBRA 1990



(d) OBRA 1993



(e) EGTRRA 2001 and JGTRRA 2003

Notes: All figures were generated with the TAXSIM calculator using an income distribution with $100 increments. The tax rates are calculated for married households filing jointly and having no children.

Figure 5: Different filtering of the time series of 2-year break-even tax rates.

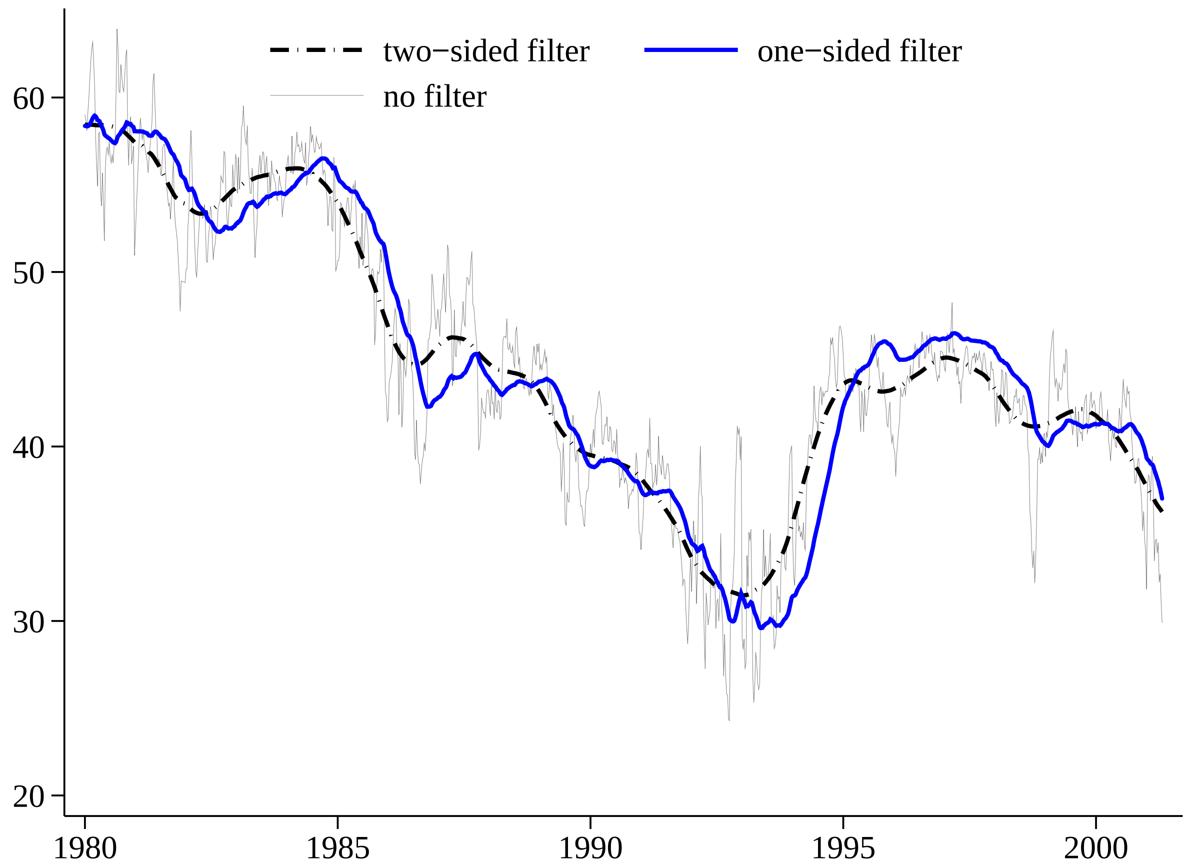
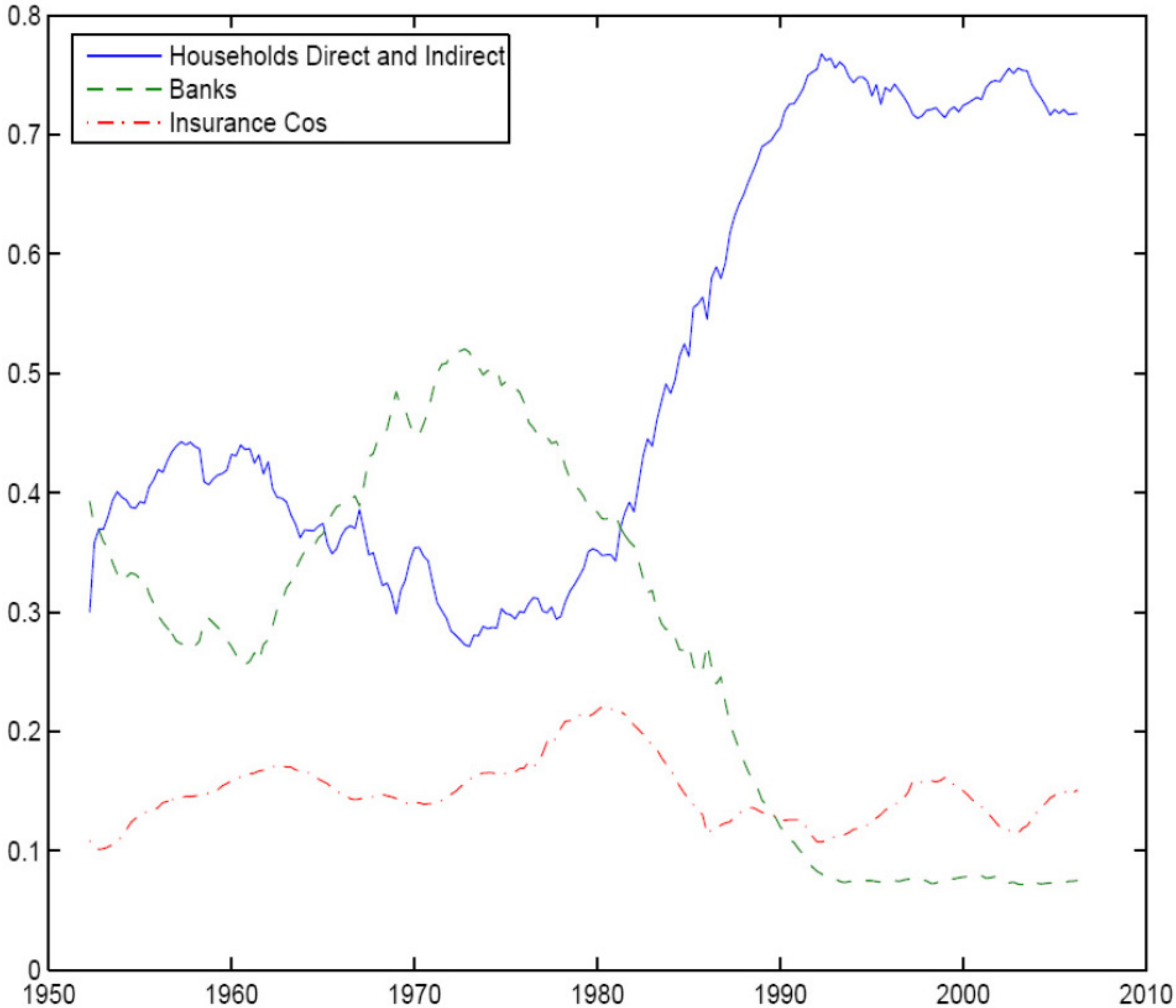
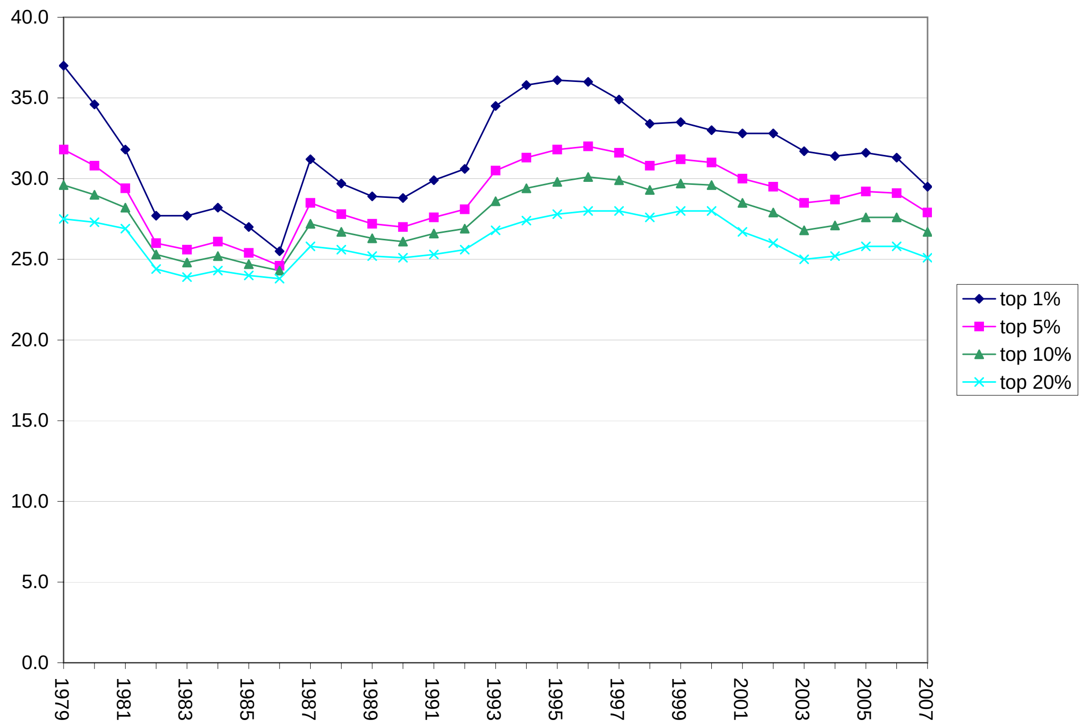


Figure 6: Municipal Debt Ownership



Source: Ang, Bhansali and Xing (2007), based on the Flow of Funds Accounts provided by the Board of Governors.
Percentage of outstanding municipal bonds held (i) by households, which includes direct ownership and indirect ownership through mutual funds, money market funds, and closed-end funds, (ii) by banks, which comprise commercial banks and savings institutions, and (iii) by insurance companies, which are life insurance companies and other insurance companies.

Figure 7: Total federal Average Tax Rates 1977-2007



Source: Congressional Budget Office (CBO).
This figure shows the time series of effective total federal average tax rates between 1977 and 2007 for households in different income percentiles. It motivates the definition of the sample of high-income households used in the paper. The average tax rates are highly but not perfectly correlated. Hence, news about the evolution of the marginal income tax rate of the marginal municipal bond investor is informative for the households' average tax rates, while at the same time allowing for time fixed effects in the estimation.